Datapolis
Exploring the Footprint of Data on Our Planet and Beyond

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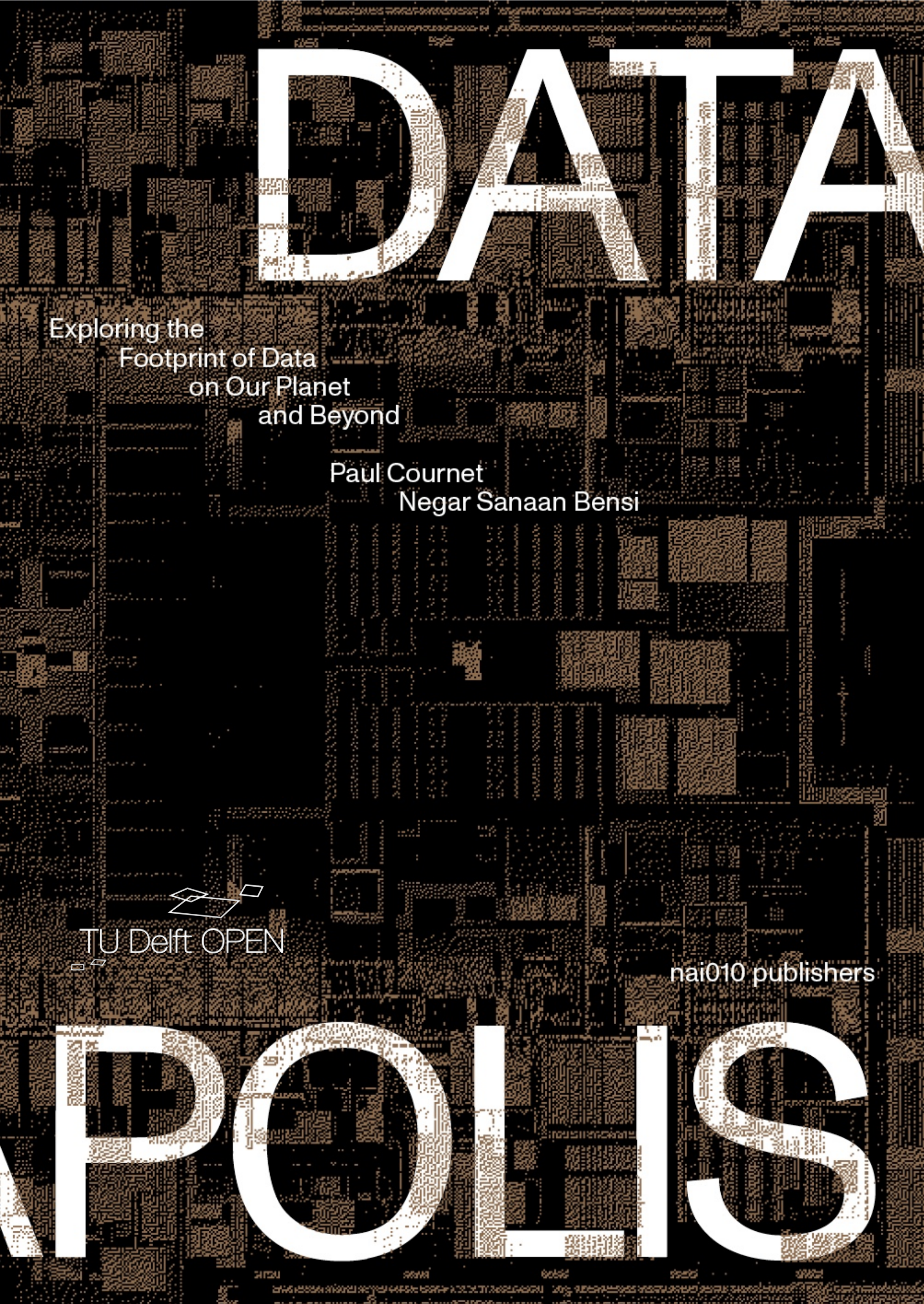


DATA

Exploring the Footprint of Data on Our Planet and Beyond

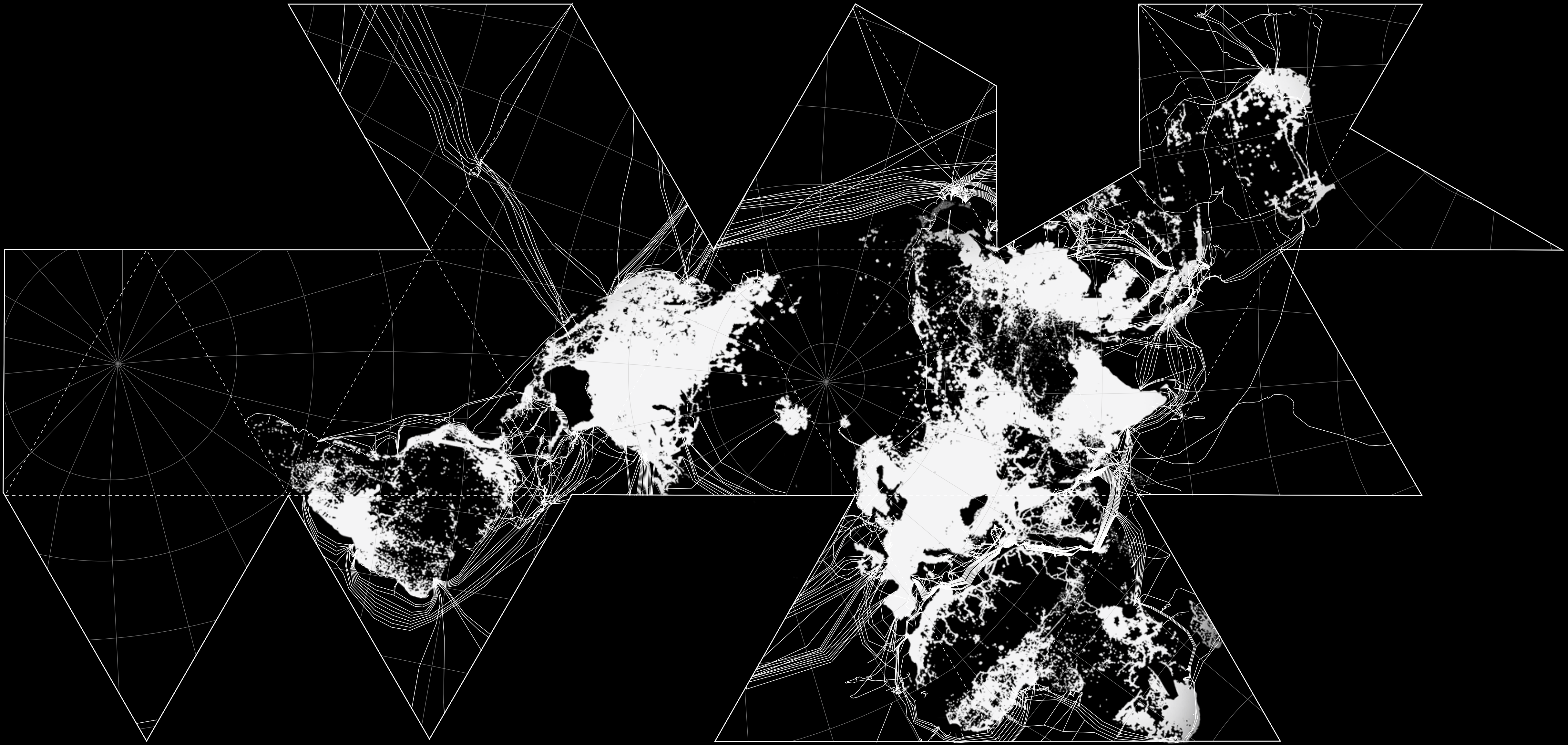
Paul Cournet
Negar Sanaan Bensi

TU Delft OPEN

nai010 publishers

POLIS

TERRITORIES OF (DIS)CONNECTION



As of 2022, there are over 1.35 million kilometers of submarine internet cables in service. Their disparate distribution across the globe reveals territories of (dis)connection. The areas represented in black are places without cell phone reception or internet Wi-Fi connection. Sources: Buckminster Fuller Institute, The White Spots Project, TeleGeography. Drawing by Léa Alapini.

DATAPOLIS

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INTRODUCTION: ON DATA

INTRODUCTION: ON DATAPOLIS

Negar Sanaan Bensi, Paul Cournet

To Be-Come Invisible

Driving in the woods near Eindhoven, in the south of the Netherlands, we are trying to navigate our route on Google Maps as the network gets weaker. This area is one of the very few zones in the country that has a low density of 5G towers. After a few hours of driving through the Dutch landscape, defined by its indefinite flatness, we finally arrive at our destination, a big cottage surrounded by trees and covered in plants. Birds are singing in the background. As we approach the cottage, we are requested to put our phones in flight mode and leave them in the car, which is parked outside the plot at a short distance. We are here to meet a community of people who suffer from EHS, or Electromagnetic hypersensitivity, generally defined as 'a claimed sensitivity to electromagnetic fields, to which negative symptoms are attributed'.[1] We sit in the garden and chat with them. 'I used to have a normal job, but over the years I've become more and more sensitive to electromagnetic fields with all of these wireless devices. I used to have intense headaches at home, at work, or even going to the city. My life became impossible. So I moved here to the forest, far from communication antennas and wireless networks,' one of the ladies explains. 'It's almost impossible to be invisible,' another states, 'this creates this constant state of anxiety.' This is the moment we realize just how much our bodies and environment have become entangled with the 'infosphere' that is a 'technical network, consisting of telegraphy, telephony, television, radio, radar, satellites, and the Internet, which covers the globe and enables global exchange of data as well as the organization of transport for people and goods',[2] but also ideas and histories. As Peter Wiebel states in the preface to the 'Infosphere' exhibition in ZKM: 'Today, people live in a globally interconnected world in which the biosphere and the infosphere are interfused and interdependent.'[3] This infosphere, however, is never smooth or homogeneous, as it is often described or anticipated within the context of globalization. Rather, it is striated and heterogeneous. It is a geopolitical sphere.

A few months after our visit to the EHS community, another very different context highlighted this entanglement of the bio- and the technosphere. The protest movement with the slogan of 'woman, life, freedom' erupted across Iran. During this time, the Internet was shut down inside the country by the government in an attempt to stop news of police violence against citizens from leaking out. Even plans for establishing a national Internet network or a new Internet-classed society to limit the access of the general population to the Internet were suggested. The aim of all such actions was to keep people in the dark and invisible.[4]

Perhaps what can be considered as a shared problem in these seemingly opposite situations resides in what Bernard Stiegler sees in the Internet as a 'pharmakon'[5] that can become 'a technique for hyper-control', leading to the state of 'social dis-integration' by submitting further to automatism. A state that results from 'the unprecedented aspect of the digital unification that it allows articulations between all these automatisms: technological, social, psychic and biological- and this is the main point of neuro-marketing and neuro-economics'[6]—and one might add neuro-politics. The logic of such processes stems from the calculative power and speed of algorithms devised in this technology to capture and exploit any traces of behavioural expressions of its users.

Hence, according to Stiegler, there exists the necessity of an 'ars of control', as a therapeutic 'invention'—and not purely as a mode of resistance as Deleuze suggested in the context of his hypothesis on 'The Societies of Control'. Through such an art—which should become ars again[7]—a new knowledge is produced, constituting new forms of existence and new ways of living, thinking, doing things, and reasoning to do things, and eventually 'new conditions of subsistence'.[8]

But that sounds like bickering with a many-headed demon.

The Many-Headed Demon

Data and its infrastructure is a many-headed demon. In the words of Benjamin Bratton, it might resemble an 'amorphous Amoeba-like creature'[9] that moves and alters its shape by extending and retracting its pseudopods to cover the Earth and its beyond. Within that amorphousness, it contains opposing forces and narratives. Something like Ravana the Indian demon, who has several heads and hands. While holding many qualities that make him a learned scholar, he is widely portrayed as an evil character who can change into any form he wishes.

Leading to an epoch that is often referred to as the information age, this many-headed demon has changed the ways we relate to our world. There have been various tendencies to describe the inherent contractions within this technosphere. Some consider this networked infrastructure, distributed in time and space, as 'the driving connective forces of much-debated processes of globalisation',[10] which stem from the powerful ideology of constructing a smooth world made of inter-networks with no hierarchy.[11] Others call it 'Surveillance Capitalism',[12] which 'claims the human experience as free raw material for its advanced manufacturing processes'[13] for a market surplus, creating giants like Google, Facebook, Apple, Microsoft and Amazon, whose control of data gives them enormous power in a so-called 'data economy'.

Today we have increasingly gotten used to inhabiting this bio-infosphere,[14] where data, algorithms, barcodes and 'the cloud' are ubiquitous to our bodies and daily activities.[15] As we slowly dissolve ourselves in living and working in the world of connectivity, regardless of time zones, geographies and political borders, we intend to forget about it. This disappearance as Timothy Morton suggests is a quality of things when they are functioning nicely in our world.[16]

Despite this ubiquity, we hardly comprehend the mechanisms of this infosphere, a complex world that can be glimpsed through tangible and intangible evidence: from the global Internet cable networks and so-called non-human architecture of data centres and IXPs to automated landscapes of factories and distribution centres; from the effect and footprint of data on the Earth to climate monitoring and the formation of global and planetary institutions; from the ownership system, political mapping and legal complexity and ambiguity of data to the appearance of digital identities; from the changing conditions of work and labour to expanded logistical systems. All these entangled complex territories, spaces, organizations, systems and entities constitute what we call Datapolis, which in our understanding requires proper exploration, analysis, conceptualization, projection and representation.

Datapolis

Datapolis was originally a research/design studio and a project that we initiated in 2019 at the Faculty of Architecture at Delft University of Technology. The Datapolis studio explored the physical and spatial aspects of data, its effect on the environment, and its relevance to architectural research and design. When we started this project, the first question simply was: What is the cloud? What is its materiality and how do we account for both the heavy weight and ephemerality of an entity such as the cloud? As we went on and the topic unfolded, we faced different angles and questions. Are data and its infrastructure merely another technological advancement for us to utilize? Is it a worldview and a mode of believing as, for example, Harari puts it in the emergence of 'Dataism'?[17] Or is it a conceptual and philosophical development in the way that, for example, Alexander Galloway discusses the concept of the digital?[18]

Datapolis is a term coined by Francis Pisani in the book, *A Journey through Smart Cities,* to describe a 'city completely managed using data collected by technological infrastructure'.[19] It sits in extreme opposition to 'Participolis', a city 'in which citizens participate in the design and management of the space in which they live'.[20] While such a binary framework is arguably problematic, it is also a reminder of Antoine Picon's statement that 'a whole array of intermediaries exist between technocratically inspired control and freely consented cooperation'.[21] He writes:

> In the domain of the smart city, we are indeed witnessing the emergence of projects inspired by neocybernetics, based on an ideal of a hierarchical control of information and of the behaviour that results from it. In contrast to this interpretation of the new urban ideal, which can easily be criticised for its technocratic tendency, is a more participatory vision founded on individuals cooperating freely, following the example of businesses such as Wikipedia ... The future intelligence of cities will reside in the coexistence of these two approaches, and above all in the interactions that such a cohabitation is sure to provoke.[22]

In this book, we follow Antoine Picon in not viewing Datapolis as the opposite of Participolis. Datapolis does not epitomize a technocratic tendency that necessarily sits in opposition to participatory visions. Instead, it is an attempt to 'give form' to the contradictory desires inherent to the idea of a city. As Massimo Cacciari explains, we want the city to work like a machine with extreme effectivity and efficiency, containing a complex of flows and functions and we also demand it to give us 'peace', to be our 'sojourn', like a 'womb' holding us safe.[23]

Datapolis is about cities in transition that due to their unstable nature cannot be reduced to any of these tendencies. Moreover, it is not 'a' city, it is always cities, territories, cultures, histories and so on. Datapolis is an invitation to explore these territories, their inhabitants, their ways of life, relations, cultures, infrastructures, organizational systems and so on. It is an invitation to join us in reading it, mapping it and conceptualizing it, as well as projecting and imagining it.

Between Thing and Data: A New Rapport

Certainly data and its infrastructure have had great technical and social impacts. Opening up questions of ontology, thinkers like Gilbert Simondon and Bruno Latour have suggested a different 'rapport' between man and 'technical object'[24] as a coupling between living and non-living. Away from its object-like instrumentalization, they refer to this rapport as a networked and complex assemblage between object-subject and object-object. In this 'open system' the relationship between human and non-human cannot be reduced to the master-slave dialectic as it was understood in traditional theories of the machine. Other important writers, like Donna Haraway, have also rejected the rigid boundaries separating 'human' from 'animal' and 'human' from 'machine'.[25] The important writings of Bernard Stiegler go one step further, stating that humans and technics are constitutive of each other. He decentralizes the concept of the human by approaching it not only as a historical or social construct, but a technical one through a process of exteriorisation—that is, by extending beyond human boundaries (bodily, cognitive and temporal) into technics (technic here is no longer opposed to culture and nature, rather it involves all sorts of arts and artefacts, including architecture).[26] In this sense, both Simondon and Stiegler are critical of [pure] automatism. For Simondon this is because of automatism's intention to exclude man and indeterminacy and hence its closed system; which is, in fact, contrary to what 'technicity' is—that is, an open system that perpetuates the co-existence and co-relation of living and non-living and is an ensemble of man and machine.[27] For Stiegler, automation's crisis stems from the analytical power of algorithms that 'are conveyed outside of any intuition in the Kantian sense—that is, outside of any experience'.[28]

The decentralization of the human in contemporary Western philosophy and its reunion with the world of objects and other beings has occurred at the same time as an increasing technological integration of our buildings, spaces and territories. With the drive towards full automatism, fundamental ontological and epistemic questions are being raised in our discipline. Currently, within the realm of architecture and urbanism the topic of data—as ambiguous as it is—is very relevant and highly debated. Many existing scholarly works have attempted to unravel the importance and impact of data on the [trans]formation of our cities, territories and spaces[29] and modes of understanding them.[30] Yet, speculations on how this can be integrated into real spatial and territorial thinking require much further work.

Fundamental questions such as: Do we need a different understanding of architecture itself? Or: Have we acquired new ways to get to know the world?[31] are now the core of many discussions in architecture, landscape and urban design. Authors like Keller Easterling remark that: 'Buildings are often no longer singularly crafted enclosures, uniquely imagined by an architect, but reproducible products set within similar urban arrangements.'[32] More than being static objects, they have become 'active forms'. A kind of thinking that is finding its way into the discussions on architecture as an affordance that can 'operate, affect, and interact as environments, entities, and beings',[33] and also considers architecture as a mediatory and manipulative procedure that articulates the configuration of information systems of spatial arrangements.[34]

Writers like Picon, on the other hand, while recognizing the shifts occurring in architecture in the aftermath of digitization and Big Data, have different ideas: to go back to the problem of meaning for the sake of reinventing or reinterpreting the fundamentals of architecture.[35] At the same time authors like Martin Pawley question totally the monumental ambitions of architecture in resolving our current technological and infrastructural mess. According to him, architecture instead can find its relevance in bringing 'together the anonymity of the "hot site", the efficiency of the "Big Shed", the ephemeralization of the petrol station, and the limitless horizons of virtual reality, and exposes all of them to the methodology of automated industrial production'.[36]

Despite the massive evolution of technology in the digital age, it is often stated that compared with other epochs where transformations were caused by technological and infrastructural developments, physically, cities have not been modified much. While Picon assumes that this morphological change is yet to happen,[37] Shannon Mattern suggests how new technologies are often being grafted onto existing infrastructures, a horticultural analogy that could provide an alternative to reinstating the city as a tree, but only if 'we learn how to recognize our urban grafts' layered and entangled manifestations, to discern the stories behind each cut and fusion, and to recognize the ethics and politics of grafting technique'.[38]

Such a reading can lead us to the expanded territories formed through these grafted technologies, taking us beyond the city itself to the massive spatial transformations that have occurred in the countryside, deep in the soil, in the oceans, and as far as outer space. These territories are where we find the physical footprints of our infosphere, laid out or submerged or floating. They suggest a need to host other inhabitants—human and non-human—within our architectural spaces. One can argue that we are witnessing a great reterritorialization of built environments, a great spatial shift that has suspended the scale of architecture somewhere between the microscopic scale of bacteria and the geologic scale of the Earth.

The Book

In this book, we intended to go beyond the mere instrumentality of digital technology and the existing discourse around digital architecture and smart cities. Instead, we are interested in data's own infrastructure, its tectonics and materiality, its inherent ethical and environmental contradictions, as well as the related political and cultural productions. For us, the challenge has been to go beyond the pure description of these systems and infrastructures as only services and backgrounds, in order to surpass the technological problem-solving mandates by placing them within wider political, economic, social, environmental and aesthetic assemblages. These assemblages have become an inherent part of the book, allowing different questions to intervene in the text through various material representations such as maps, different forms of drawings, photographs and texts.

In the book, we follow two main trajectories: the first trajectory is an ontological investigation per se. It attempts to define what 'the cloud' is and how it operates. From the systems and infrastructures behind the Internet to the apparatus, gizmos and buildings that can transcend scales and temporal dimensions. Not only do we map, read and analyse, but we also look into alternative conceptualizations and projections. The second trajectory tries to explore how data penetrates our existence, not only by affecting the ways we live and work, or design and make cities, but by offering distinct ways of life and organization that otherwise would not have been possible. On the one hand, we investigate data as an ethical and political phenomenon. On the other, we perceive how data through its apparatus and sensors gives agency to things that previously had no voice, gives 'visibility' to invisible things, and forms new imaginaries.

The book is structured like a barcode, it represents the combination of the different textual and visual materials that we produced and gathered throughout the process. It contains four main chapters that can be read or looked at autonomously, and yet are complementary. Many intersections and interrelations are floating thematically between different chapters, and we hope that the reader will enjoy exploring them.

The first chapter is an elongated introduction, including maps that question the European-centric representation of data infrastructures, a timeline that calls for multiplicity and non-linearity in history and reveals the gaps in the existing historiographies of technology. It narrates alternative stories of infrastructural spaces. The emergence of digital technology is rooted in changes in theories and inventions, software and hardware, episteme and technical objects, modes of learning and doing, perceiving and projecting and hence it cannot be perceived linearly. It is a series of entangled events that form the infosphere we live in today. While paradoxically the notion of the timeline suggests a linearity of events, we state that an oligopticon[39] reading of it allows for the multiplicity of narratives to emerge and intersect. Hence, the presented retroactive timeline illustrates a possibility for transversal rather than linear readings of events through several different narratives, superposing the apparent linearity of the background. As the number of narratives increases, the constellation of lines and points will take over the linear organization of events. The timeline is accompanied by a text by Georg Vrachliotis, 'Notes on an Archaeology of Design Data Literacy', which adds another narrative to such a constellation.

The chapter ends with the Catalogue of Gizmos, which suggests alternative relationships between technical objects, other beings and the human body. As Kees Kaan suggests in the glossary of his text 'On Gizmos, Gadgets, Objects and Data', 'the gizmo is a weird gadget whose real name and use has been forgotten'. In this sense these objects almost need to be revisited and their places reallocated in our world.

The second chapter focuses on a grounded investigation of data infrastructure and the automated landscapes that are heavily dependent on it. Through a photographic journey in the Netherlands, Paul Swagerman explores the layered boundaries, materiality, aesthetics, spatial and organizational complexity of data [infra]structures and highly automated landscapes that are sometimes devoid of human presence, and are often hidden within vast ubiquitous boxes or under the ground in the bunkers inherited from the World Wars. Through a rather personal gaze, this collection documents the observations of the photographer while visiting nine different locations in the country: the point where the undersea Internet cable reaches the land from the North Sea, the buildings storing data online or offline, the landscapes of highly automated industries and logistical landscapes, all the way to a counter-narrative for the Datapolis, where the struggle for invisibility is practiced daily by communities in the least connected parts of the country, in the forests or deserted dune landscapes.

The third chapter contains all the textual contributions to the book. It involves a young generation of authors, artists and designers who reflect on data, its infrastructure and agency. From different angles, the papers in this chapter present alternative conceptions and readings of data and its infrastructure. In her paper ‘From Data Centre to Data Forest’, Marina Otero Verzier delves into new architectural paradigms for storing data, attuned to social and ecological challenges, such as plant-DNA storage. She then encourages us to imagine the forest as the potential paradigm of a non-Cartesian, situated and open-ended data-storing architecture. In her paper ‘Vibrant Data: The Sewer as Information Infrastructure’, Sabrina Chou foregrounds the sewer as an information infrastructure, by tracing flows of faecal data and digital information to gesture towards an embodied metaphysical conception of data as a vibrant, relational and social substance. Following Chou, Ali Fard, in his paper ‘On the Sociotechnical Production of Planetary Platforms’, unravels technology platforms as well-designed sociotechnical entities that combine ideology, myth and marketing to construct amorphous and all-encompassing narratives, while actively hiding their dependence on the infrastructural landscapes, material geographies and operational extensions. Departing from the metaphor of the digital cloud, in her paper ‘The Digital Cloud: Between Geological Extraction and Meteorological Hyper-Responsiveness’, Natalie P. Koerner explores the spatialities, materialities and temporalities of data centres. Describing and unpacking the cloud through planetary analogies, she questions the innate neo-colonial injustices embedded in the material reliance of ‘the cloud’ on earth minerals, extraction and climate politics.

One of the most apparent and important changes facilitated by data flows and digital technology has happened in our abilities to see, remodel, represent and navigate. These new technologies have raised fundamental questions not only about how we perceive, relate to and imagine the space we inhabit, but also about the way we monitor, survey and surveil the environment and people.[40] Departing from these questions, Gökçe Önal, in her paper ‘“Here Be Dragons”: The Liminal Topographies of Statistical Imaging’, problematizes the all-seeing capacity associated with the accuracy of digital earth engines, arguing for an unseen ecology of energetic gaps, numeric approximations and rejected probability distributions growing together with the visible end of our cartographic screens. In the following contribution, Joost Grootens, in his paper ‘This Way: Expressive Self-Tracking as Creative Practice’, addresses the surveillance issues surrounding satellite navigation and fitness apps, as well as the economic models employed by the technology companies running the latter. Through a post-representational reading of GPS drawing, he emphasizes the ambiguity of authorship and the degree of completeness of digital production.

Extending on the topic of remodelling our world via digital technologies, in her paper ‘Blockchain and the Real-Estate-Media Complex’, Marija Marić shows how the emergence of fractional ownership and entire markets for developing and trading digital land has prompted the real-estate market to be organized around the uses and promises of blockchain technologies. She rightfully argues for a deeper understanding of such technologies, not only as technical innovations but above all as new imaginaries of social coordination and trust, based on their capacity to redefine our property relationship with the built environment and reappropriate the urban commons. Following Marić, in his artistic work ‘Life Needs Internet: Handwritten Letters on Digital Culture’, Jeroen van Loon archives the global influences of the Internet on our lives through local and personal testimonials, and intimate stories. Through these individual stories, he brings situated views that sometimes exceed their local and temporal coordinates and find commonalities.

The last chapter of the book includes the works produced by the students of Datapolis Studio. This chapter envisions other possibilities to, as Rania Ghosn and El Hadi Jazairy suggest ‘speculate on ways of living with’[41] the legacy of Datapolis, as a way for architecture to intervene and project imaginaries that can assemble again the technical, political, social, environmental and aesthetic, and give them form. In these visions, architecture brings together the various scales, systems, things and spaces that often remain unrelated. It is exactly in the making of these relations and alternative scenarios that architecture finds its relevance, which is mostly visible in the projection and organization of the final drawings. The architectural drawing is a strong speculative medium to investigate and represent possible scenarios for the gatherings of technology and environment. The final drawings of each project were originally made at a large scale, 841 × 1189 mm in size, with a high level of detail. The nature of these drawings has meant that they are difficult to fit within the format of this book, but we have shown excerpts and details to illustrate particular points. This series of projects touch upon various themes, some of which have also been addressed in texts and visual forms of photographs in other chapters.

This book has been published in a trade version (printed and e-book) and this academic version (open access). The trade version contains three additional essays, already published works by Kate Crawford, Shannon Mattern and Ruha Benjamin, which are not included in this open-access. Together, they form a trilogy about technology on Earth, Grafts and Race.

To conclude, the ambition of this book was to become a platform to explore different spectrums, perspectives, opportunities and challenges that digitization poses to the thinking and making of our environment, and in that sense, we do not claim to have reached solutions. We have tried to go beyond the opposing narratives on technology— that is, emancipation or oppression— and have instead explored the complex assembly of layered immanent forces within Datapolis. Bringing such an assembly to spatial thinking, we have often reminded ourselves to not lean towards one form of intelligence over another. Instead, we have asked whether it is possible, to integrate and assemble various forms of intelligence in our imaginaries, worlds, spaces and cities—that is, in our Datapolis.

Notes

1 Wikipedia, Electromagnetic Hyper Sensitivity.

2 Peter Wiebel, preface, Infosphere: The Transformation of Things into Data, ZKM, https://zkm.de/en/exhibition/2017/05/infosphere.

3 Ibid.

4 In recent years, we have seen around the world the increasing role of data and Internet on various sociopolitical events. For example, during the 2019 Hong-Kong protests, one of the largest series of demonstrations in the history of Hong Kong, the data infrastructure was employed both by the police and the protestors: to identify and control the protests in the first case, and to organize and create new tactics of fluidly moving the protestors, in the second case. Or the escalation of Internet censorships during the Arab Spring on the one hand and the role of Social media as enabling and facilitating the voice of the protestors on the other. Or the rise of radical groups on social media platforms and their impact on election poles in the United States—and so on.

5 According to Stiegler, because Internet is originally technological it can, like every other technics, be ambivalent, and hence be a pharmakon in its designated Greek meaning: ‘At once the poison, the cure and the scapegoat.’ Bernard Stiegler, Colette Tron and Daniel Ross, ‘Ars and Organological Inventions in Societies of Hyper-Control’, *Leonardo* 49/5 (2016), 480–484.

6 Ibid., 482.

7 *Ars* is the Latin equivalent of the Greek *techne*. ‘The diminutive of “ars” is “articulum”—i.e. “a little art”’. When Stiegler suggests that art becomes ‘ars’, he means that art meets ‘techne’, to literally be skillful again, standing both for knowledge and know-how. So for ‘art of hyper-control’ to be a ‘therapeutic invention’, it would ‘need to be inseparable from a juridical, philosophical, scientific, political and economic inventiveness’. Ibid., 483.; Vilém Flusser and John Cullars, ‘On the Word Design: An Etymological Essay’, *Design Issues* 11/3 (1995), 50–53.

8 Ibid., 481.

9 Benjamin Bratton, *The Terraforming* (Moscow: Strelka Press, 2019).

10 Stephen Graham and Simon Marvin, *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition* (London: Routledge & Kegan Paul, 2001), 8.

11 Stephen Graham and Simon Marvin explain that in the Western world, since the Second World War, a powerful ideology has been built of how we perceive the infrastructural networks as services that ‘add cohesion to territory’ and ‘bind cities, regions and nations into functioning geographical or political wholes’ and are ‘freely available to all individual at equal costs within a particular administrative area’. Ibid.

12 Shoshana Zuboff, *The Age of Surveillance Capitalism: The Fight for the Future at the New Frontier of Power* (London: Profile Books, 2019).

13 Ibid., 14.

14 This bio-infosphere is a new assemblage, a multiplicity that is made up of heterogeneous spheres constituting a new world.

15 It goes without saying that this state of living is not equally smooth everywhere, but certainly its presence and effects are extended everywhere on Earth and beyond.

16 Timothy Morton, *Being Ecological* (Cambridge, MA: MIT Press, 2018), 45.

17 Yuval N. Harari, *Homo Deus: A Brief History of Tomorrow* (New York: Harper Collins, 2017).

18 Alexander Galloway, *Laruelle: Against the Digital* (Minneapolis: University of Minnesota Press, 2014); Alexander Galloway, ‘Golden Age of Analog’, *Critical Inquiry* 48/2 (2022), 211–232.

19 Francis Pisani, *A Journey through Smart Cities: Between Datapolis and Participolis* (UNESCO/Netexplo Observatory, 2015), 9.

20 Ibid.

21 Antoine Picon, *Smart Cities: A Spatialised Intelligence* (Chichester: Wiley, 2015), 16.

22 Ibid.

23 Massimo Cacciari, ‘Nomads in Prison’, *Casabella* 705 (2002), 106–108.

24 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, translated by Cécile Malaspina and John Rogove (Minneapolis: Univocal Publishing, 2017).

25 Donna Haraway, ‘A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century’, in: Donna Haraway, *Simians, Cyborgs and Women: The Reinvention of Nature* (New York; Routledge, 1991), 149–181.

26 Bernard Stiegler, *Technics and Time, 1: The Fault of Epimetheus*, translated by Richard Beardsworth and George Collins (Stanford: Stanford University Press, 1989 [1994]); Robert Alexander Gorny and Andrej Radman, ‘From Epiphylogenesis to General Organology’, *Footprint* 16/1 (2022), 3–20; Andrés Vaccari and Belinda Barnet, ‘Prolegomena to a Future Robot History: Stiegler, Epiphylogenesis and Technical Evolution’, *TRANSFORMATIONS Journal of Media & Culture* 17, Bernard Stiegler and the Question of Technics (2009).

27 Simondon, *On the Mode of Existence*, op. cit (note 24).

28 Bernard Stiegler et al., ‘Ars and Organological Inventions’, op. cit. (note 5), 480.

29 See, for example: Anthony M. Townsend, *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia* (New York: W.W. Norton & Company, 2013), or several books by William J. Mitchell or the writings of Carlo Ratti on the impact of Big Data and digital technologies on city and architecture.

30 See, for example: Michael Batty, *The New Science of Cities* (Cambridge, MA: MIT Press, 2013).

31 Weaving Worlds: speculations between affect & evidence, https://www.weaving.world

32 Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (London: Verso, 2014).

33 Jenny Sabin, ‘Transformative Research Practice: Architectural Affordances and Crisis’, *Journal of Architectural Education* 69/1 (2015), 63–71.

34 Michael Barton, ‘Synphronesis’, in: Amir Ameri and Rebecca O’Neal Dagg (eds.), *The Ethical Imperative:106th Annual Meeting* (New York: ACSA, 2018), 443–445.

35 Antoine Picon, *Digital Culture in Architecture: An Introduction for the Design Professions* (Basel: Birkhäuser/Springer Verlag, 2010).

36 Martin Pawley, *Terminal Architecture* (London: Reaktion Books,1998).

37 Picon, *Smart Cities*, op. cit. (note 21).

38 Shannon Mattern, *The City Is Not a Computer: Other Urban Intelligences* (Princeton, NJ: Princeton University Press, 2021), 11.

39 Bruno Latour proposed the oligoptican (and oligoptica) in confrontation with Michel Foucault’s use of ‘panoptican’, as an ideal of a total surveillance, and ‘panorama’ as the representation of a total view. Instead, he suggests to allow for the multitude of more localized and heterogeneous relations, views, realities and actors to intertwine. Oligoptica was a medium through which Latour could practice and visualize his ideas of actor-network theory ‘to trace more sturdy relations and discover more revealing patterns by finding a way to register the links between unstable and shifting frames of reference rather than by trying to keep one frame stable’. Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005); Bruno Latour, Emilie Hermant and Susanna Shannon, *Paris ville invisible* (Paris: La Découverte, 1998), translated from the French by Liz Carey-Libbrecht as *Paris: Invisible City*, http://www.bruno-latour.fr/sites/default/files/downloads/viii_paris-city-gb.pdf.

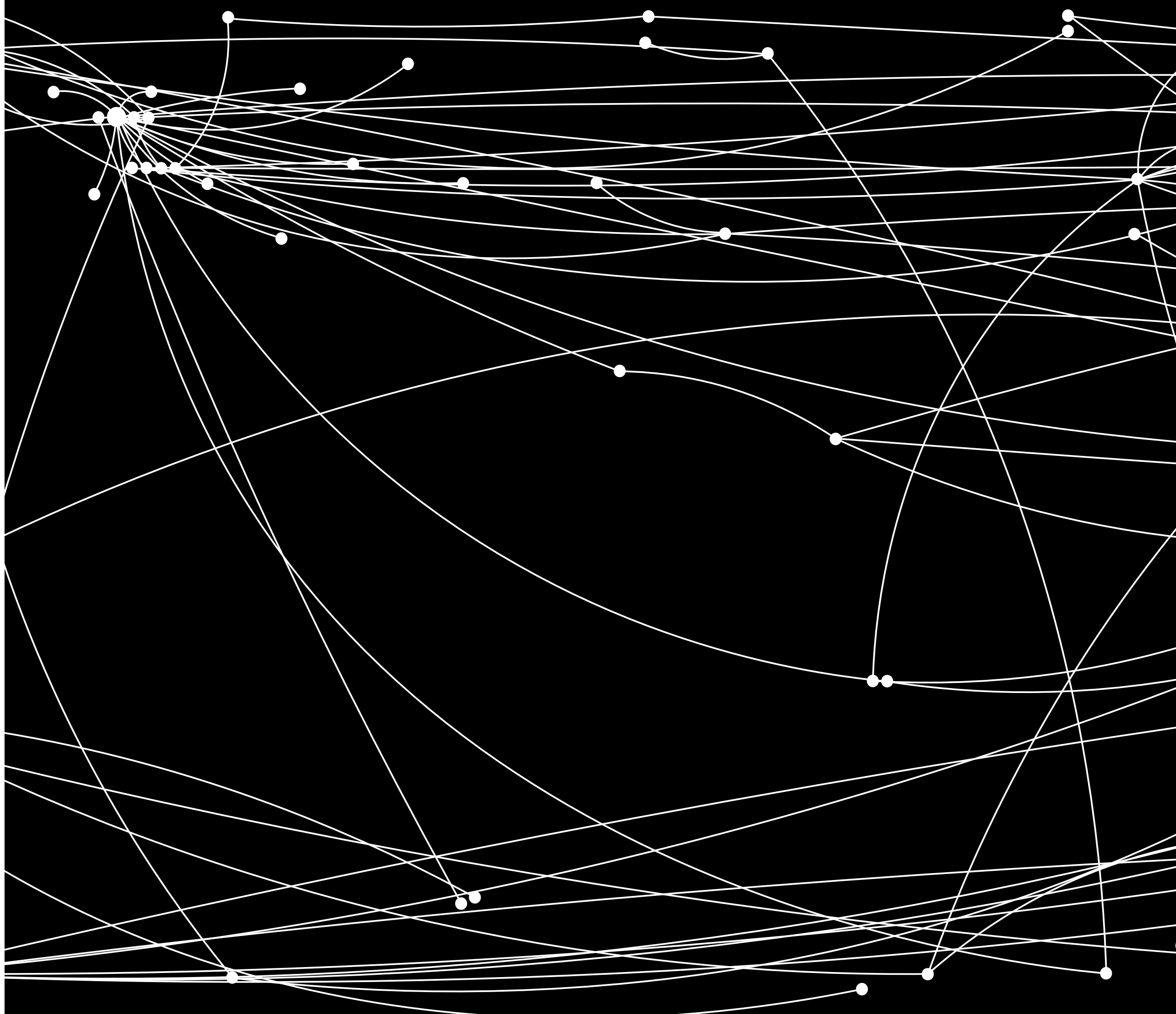
40 Laura Kurgan, *Close Up at a Distance: Mapping Technology and Politics* (New York: Zone Books, 2013).

41 Ghosn Rania, El Hadi Jazairy and Design Earth (Firm), *Geostories : Another Architecture for the Environment* (New York NY USA: Actar, 2018).

RETROACTI

RETROACTIVE TIMELINE OF DATA INFRASTRUCTURE

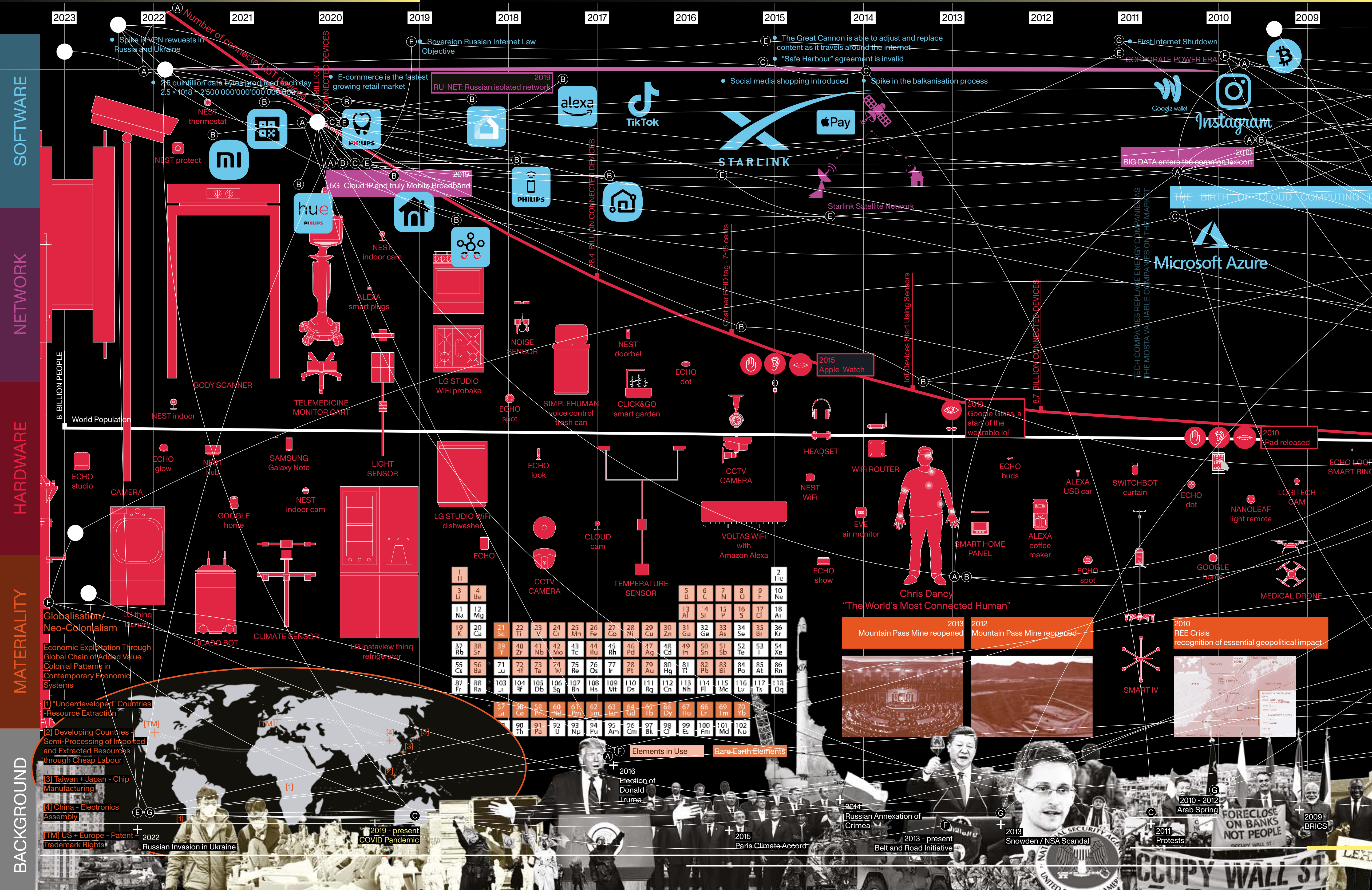
Patrycja Raszka, Theodor Reinhardt, Fabio Sala, Yiyin Yu



TIMELINE
extended version

EDGE OF TOMORROW

DA



- Spike in VPN rewuests in Russia and Ukraine
- 2.5 quintillion data bytes produced each day
  2.5 × 1018 = 2'500'000'000'000'000'000
- E-commerce is the fastest growing retail market
- Sovereign Russian Internet Law Objective
- The Great Cannon is able to adjust and replace content as it travels around the internet
- "Safe Harbour" agreement is invalid
- Social media shopping introduced
- Spike in the balkanisation process
- First Internet Shutdown

CORPORATE POWER ERA

2019
RU-NET: Russian isolated network

2019
5G Cloud IP and truly Mobile Broadband

2010
BIG DATA enters the common lexicon

THE BIRTH OF CLOUD COMPUTING T

2015
Apple Watch

2013
Google Glass, a start of the wearable IoT

2010
iPad released

Chris Dancy
"The World's Most Connected Human"

2013
Mountain Pass Mine reopened

2012
Mountain Pass Mine reopened

2010
REE Crisis
recognition of essential geopolitical impact

Elements in Use

Rare Earth Elements

Globalisation/
Neo-Colonialism

Economic Exploitation Through Global Chain of Added Value Colonial Patterns in Contemporary Economic Systems

[1] "Underdeveloped" Countries -Resource Extraction

[2] Developing Countries - Semi-Processing of Imported and Extracted Resources through Cheap Labour

[3] Taiwan + Japan - Chip Manufacturing

[4] China - Electronics Assembly

[TM] US + Europe - Patent + Trademark Rights

2022
Russian Invasion in Ukraine

2019 - present
COVID Pandemic

2016
Election of Donald Trump

2015
Paris Climate Accord

2014
Russian Annexation of Crimea

2013 - present
Belt and Road Initiative

2013
Snowden / NSA Scandal

2011
Protests

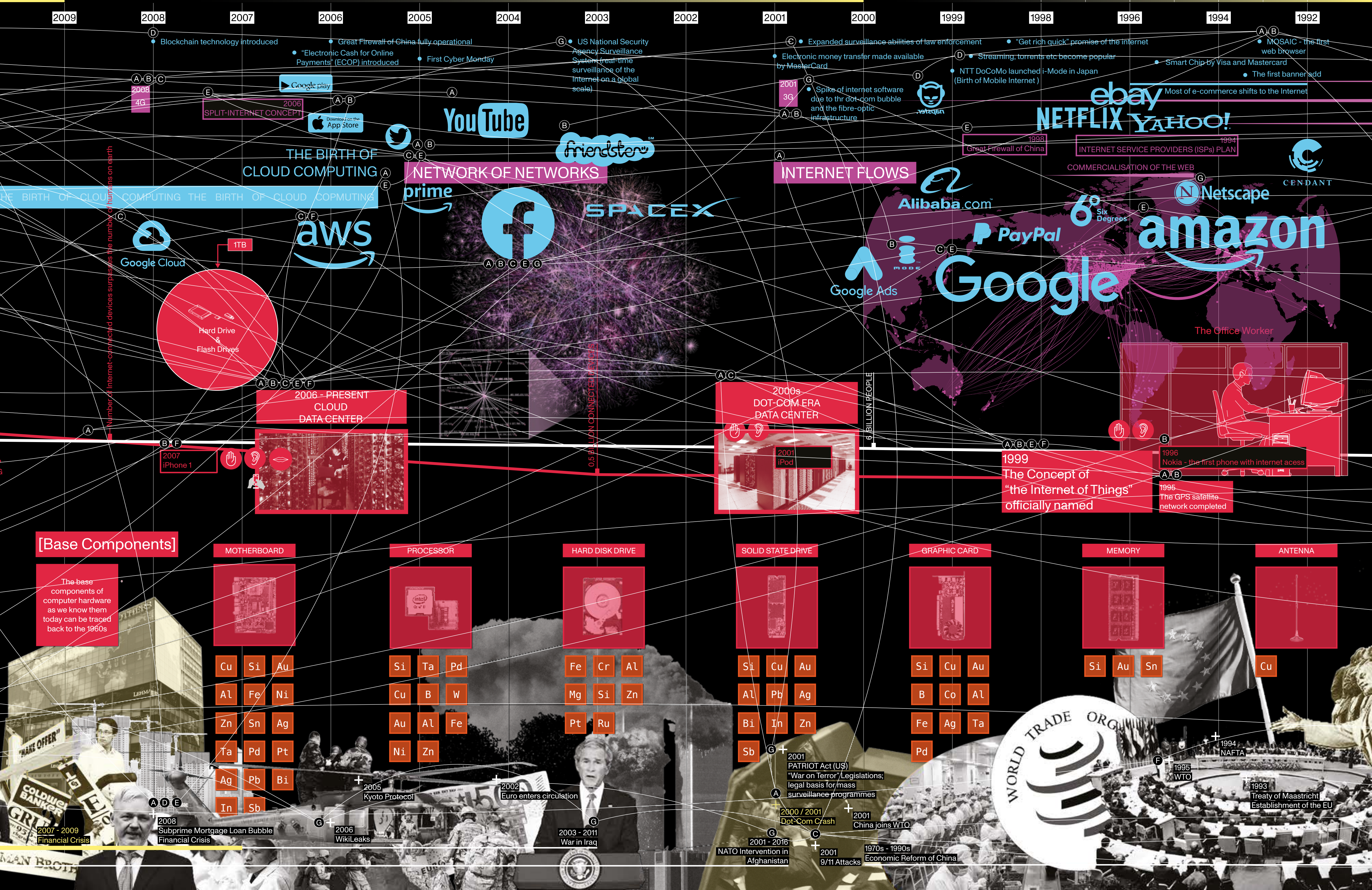
2010 - 2012
Arab Spring

2009
BRICS

TAISM

NEW MILLENIUM

END



- Blockchain technology introduced
- Great Firewall of China fully operational
- "Electronic Cash for Online Payments" (ECOP) introduced
- First Cyber Monday
- US National Security Agency Surveillance System (real-time surveillance of the Internet on a global scale)
- Expanded surveillance abilities of law enforcement
- Electronic money transfer made available by MasterCard
- Spike of internet software due to thr dot-com bubble and the fibre-optic infrastructure
- "Get rich quick" promise of the internet
- Streaming, torrents etc become popular
- NTT DoCoMo launched i-Mode in Japan (Birth of Mobile Internet)
- MOSAIC - the first web browser
- Smart Chip by Visa and Mastercard
- The first banner add

2008
4G

2006
SPLIT-INTERNET CONCEPT

2001
3G

Most of e-commerce shifts to the Internet

1998
Great Firewall of China

1994
INTERNET SERVICE PROVIDERS (ISPs) PLAN

COMMERCIALISATION OF THE WEB

THE BIRTH OF CLOUD COMPUTING

HE BIRTH OF CLOUD COMPUTING THE BIRTH OF CLOUD COPMUTING

NETWORK OF NETWORKS

INTERNET FLOWS

Number of Internet-connected devices surpasses the number of humans on earth

Hard Drive & Flash Drives

2006 - PRESENT CLOUD DATA CENTER

0,5 BILLION CONNECTED DEVICES

2007
iPhone 1

2000s DOT-COM ERA DATA CENTER

2001
iPod

6 BILLION PEOPLE

The Office Worker

1999
The Concept of "the Internet of Things" officially named

1996
Nokia - the first phone with internet acess

1995
The GPS satellite network completed

[Base Components]

The base components of computer hardware as we know them today can be traced back to the 1960s

MOTHERBOARD		
Cu	Si	Au
Al	Fe	Ni
Zn	Sn	Ag
Ta	Pd	Pt
Ag	Pb	Bi
In	Sb	

PROCESSOR		
Si	Ta	Pd
Cu	B	W
Au	Al	Fe
Ni	Zn	

HARD DISK DRIVE		
Fe	Cr	Al
Mg	Si	Zn
Pt	Ru	

SOLID STATE DRIVE		
Si	Cu	Au
Al	Pb	Ag
Bi	In	Zn
Sb		

GRAPHIC CARD		
Si	Cu	Au
B	Co	Al
Fe	Ag	Ta
Pd		

MEMORY		
Si	Au	Sn

ANTENNA
Cu

2007 - 2009
Financial Crisis

2008
Subprime Mortgage Loan Bubble
Financial Crisis

2006
WikiLeaks

2005
Kyoto Protocol

2002
Euro enters circulation

2003 - 2011
War in Iraq

2001
PATRIOT Act (US)
"War on Terror" Legislations; legal basis for mass surveillance programmes

2000 / 2001
Dot-Com Crash

2001 - 2016
NATO Intervention in Afghanistan

2001
9/11 Attacks

2001
China joins WTO

1970s - 1990s
Economic Reform of China

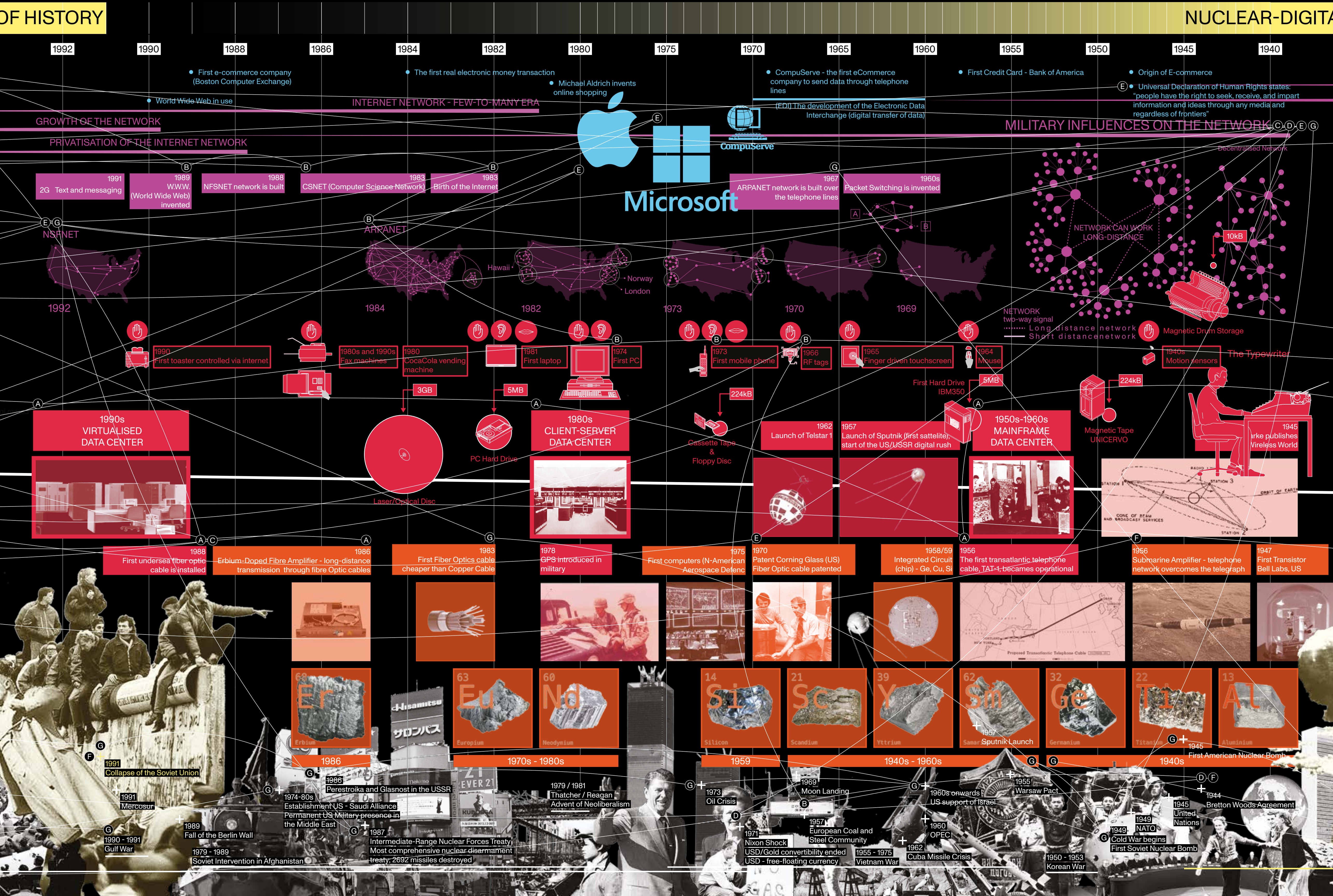
1995
WTO

1994
NAFTA

1993
Treaty of Maastricht
Establishment of the EU

OF HISTORY

NUCLEAR-DIGITA



1992 1990 1988 1986 1984 1982 1980 1975 1970 1965 1960 1955 1950 1945 1940

- First e-commerce company (Boston Computer Exchange)
- World Wide Web in use
- The first real electronic money transaction
- Michael Aldrich invents online shopping
- CompuServe - the first eCommerce company to send data through telephone lines
- (EDI) The development of the Electronic Data Interchange (digital transfer of data)
- First Credit Card - Bank of America
- Origin of E-commerce
- Universal Declaration of Human Rights states: "people have the right to seek, receive, and impart information and ideas through any media and regardless of frontiers"

INTERNET NETWORK - FEW-TO-MANY ERA

GROWTH OF THE NETWORK

PRIVATISATION OF THE INTERNET NETWORK

MILITARY INFLUENCES ON THE NETWORK

Decentralised Network

1991
2G Text and messaging

1989
W.W.W.
(World Wide Web)
invented

1988
NFSNET network is built

1983
CSNET (Computer Science Network)

1983
Birth of the Internet

1967
ARPANET network is built over the telephone lines

1960s
Packet Switching is invented

NSFNET

ARPANET

Hawaii

Norway

London

1992 1984 1982 1973 1970 1969

NETWORK CAN WORK LONG-DISTANCE

10kB

NETWORK
two-way signal
Long distance network
Short distance network

Magnetic Drum Storage

1990
First toaster controlled via internet

1980s and 1990s
Fax machines

1980
CocaCola vending machine

1981
First laptop

1974
First PC

1973
First mobile phone

1966
RF tags

1965
Finger driven touchscreen

1964
Mouse

1940s
Motion sensors

The Typewriter

3GB
Laser/Optical Disc

5MB
PC Hard Drive

224kB
Cassette Tape
&
Floppy Disc

First Hard Drive
IBM350
5MB

224kB
Magnetic Tape
UNICERVO

1990s
VIRTUALISED
DATA CENTER

1980s
CLIENT-SERVER
DATA CENTER

1962
Launch of Telstar 1

1957
Launch of Sputnik (first sattelite), start of the US/USSR digital rush

1950s-1960s
MAINFRAME
DATA CENTER

1945
arke publishes
Vireless World

1988
First undersea fiber optic cable is installed

1986
Erbium-Doped Fibre Amplifier - long-distance transmission through fibre Optic cables

1983
First Fiber Optics cable cheaper than Copper Cable

1978
GPS introduced in military

1975
First computers (N-American Aerospace Defenc

1970
Patent Corning Glass (US)
Fiber Optic cable patented

1958/59
Integrated Circuit (chip) - Ge, Cu, Si

1956
The first transatlantic telephone cable, TAT-1, becames operational

1956
Submarine Amplifier - telephone network overcomes the telegraph

1947
First Transistor
Bell Labs, US

68 Er Erbium

63 Eu Europium

60 Nd Neodymium

14 Si Silicon

21 Sc Scandium

39 Y Yttrium

62 Sm Samar

32 Ge Germanium

22 Ti Titan

13 Al Aluminium

1986

1970s - 1980s

1959

1940s - 1960s

1940s

1991
Collapse of the Soviet Union

1991
Mercosur

1990 - 1991
Gulf War

1989
Fall of the Berlin Wall

1979 - 1989
Soviet Intervention in Afghanistan

1986
Perestroika and Glasnost in the USSR

1974-80s
Establishment US - Saudi Alliance
Permanent US Military presence in the Middle East

1987
Intermediate-Range Nuclear Forces Treaty
Most comprehensive nuclear disarmament treaty; 2692 missiles destroyed

1979 / 1981
Thatcher / Reagan
Advent of Neoliberalism

1973
Oil Crisis

1971
Nixon Shock
USD/Gold convertibility ended
USD - free-floating currency

1969
Moon Landing

1957
European Coal and Steel Community

1955 - 1975
Vietnam War

1960s onwards
US support of Israel

1960
OPEC

1962
Cuba Missile Crisis

1957
Sputnik Launch

1955
Warsaw Pact

1950 - 1953
Korean War

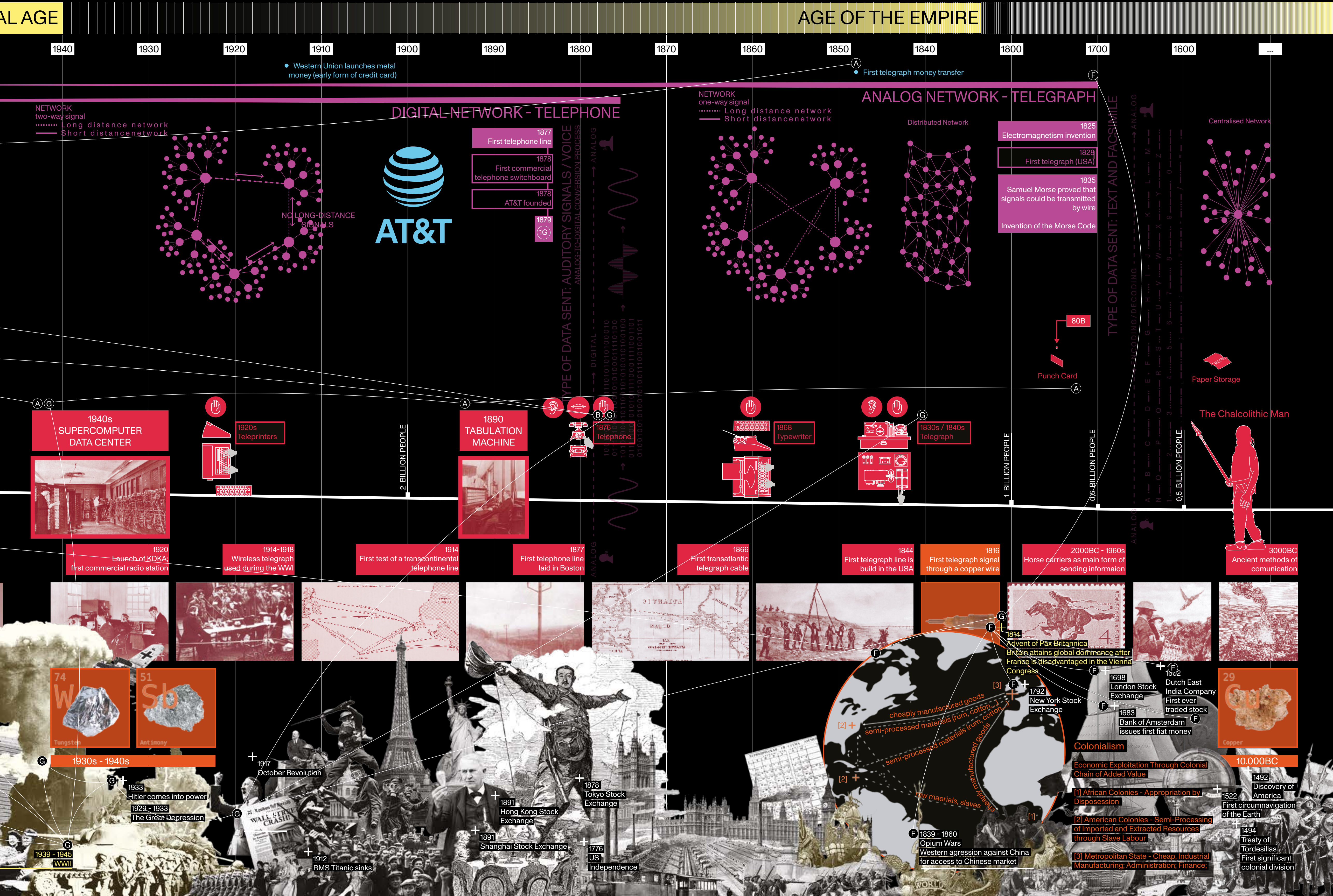
1949
Cold War begins
First Soviet Nuclear Bomb

1949
NATO

1945
United Nations

1945
First American Nuclear Bomb

1944
Bretton Woods Agreement



AL AGE

AGE OF THE EMPIRE

1940 1930 1920 1910 1900 1890 1880 1870 1860 1850 1840 1800 1700 1600 ...

Western Union launches metal money (early form of credit card)

Ⓐ First telegraph money transfer

DIGITAL NETWORK - TELEPHONE

NETWORK
two-way signal
Long distance network
Short distancenetwork

NO LONG-DISTANCE SIGNALS

AT&T

1877
First telephone line

1878
First commercial telephone switchboard

1878
AT&T founded

1879
1G

TYPE OF DATA SENT: AUDITORY SIGNALS / VOICE
ANALOG-TO-DIGITAL CONVERSION PROCESS
ANALOG → DIGITAL → ANALOG

ANALOG NETWORK - TELEGRAPH

NETWORK
one-way signal
Long distance network
Short distancenetwork

Distributed Network

1825
Electromagnetism invention

1828
First telegraph (USA)

1835
Samuel Morse proved that signals could be transmitted by wire

Invention of the Morse Code

TYPE OF DATA SENT: TEXT AND FACSIMILE
ANALOG → ENCODING/DECODING → ANALOG

Centralised Network

80B

Punch Card

Paper Storage

The Chalcolithic Man

1940s
SUPERCOMPUTER DATA CENTER

1920s
Teleprinters

2 BILLION PEOPLE

1890
TABULATION MACHINE

1876
Telephone

1868
Typewriter

1830s / 1840s
Telegraph

1 BILLION PEOPLE

0,6 BILLION PEOPLE

0,5 BILLION PEOPLE

1920
Launch of KDKA;
first commercial radio station

1914-1918
Wireless telegraph
used during the WWI

1914
First test of a transcontinental telephone line

1877
First telephone line
laid in Boston

1866
First transatlantic telegraph cable

1844
First telegraph line is build in the USA

1816
First telegraph signal through a copper wire

2000BC - 1960s
Horse carriers as main form of sending informaion

3000BC
Ancient methods of comunication

74 W Tungsten

51 Sb Antimony

29 Cu Copper

1930s - 1940s

10.000BC

1917
October Revolution

1933
Hitler comes into power

1929 - 1933
The Great Depression

1939 - 1945
WWII

1912
RMS Titanic sinks

1891
Hong Kong Stock Exchange

1891
Shanghai Stock Exchange

1878
Tokyo Stock Exchange

1776
US Independence

1814
Advent of Pax Britannica
Britain attains global dominance after France is disadvantaged in the Vienna Congress

1792
New York Stock Exchange

1698
London Stock Exchange

1602
Dutch East India Company
First ever traded stock

1683
Bank of Amsterdam issues first fiat money

cheaply manufactured goods
semi-processed materials (rum, cotton,...)
semi-processed materials (rum, cotton,...)
cheaply manufactured goods
raw maerials, slaves
[1] [2] [2] [3]

1839 - 1860
Opium Wars
Western agression against China for access to Chinese market

Colonialism

Economic Exploitation Through Colonial Chain of Added Value

[1] African Colonies - Appropriation by Disposession

[2] American Colonies - Semi-Processing of Imported and Extracted Resources through Slave Labour

[3] Metropolitan State - Cheap, Industrial Manufacturing; Administration; Finance;

1492
Discovery of America

1522
First circumnavigation of the Earth

1494
Treaty of Tordesillas
First significant colonial division

NOTES ON AN ARCHAEO

NOTES ON AN ARCHAEOLOGY OF DESIGN DATA LITERACY

Georg Vrachliotis

‘In recent years, “data” has become one of the most important aspects of architectural design. With the advent of new technologies, architects are now able to collect and analyse data about everything from building materials to weather patterns. This data can be used to create more efficient and sustainable buildings. In some cases, data can even be used to create entire new neighbourhoods or cityscapes.’ The sentences sound like a quote, one that could have come from an interview about the history of digital culture or the interconnections between architecture and technology. But as authentic as this statement sounds, it was never said. Anyone who thinks they hear the voice of an architect, computer scientist or historian is mistaken. Strictly speaking, the words do not come from a human being, but from the language software Generative Pre-Trained Transformer, GPT-3 for short. The program is the third generation of artificial intelligence, considered one of the most impressive products our digital culture has produced to date. On a timeline of disruptive technologies, it currently occupies the most current position. GPT-3 is a text generator that can write poems and dramas, provide answers to complex questions on topics such as love or trust, discuss the weather or international climate policy with us—and that has also written the short statement on the subject of ‘data and architectural design’ mentioned above. The *New York Times* calls the program ‘amazing, spooky, humbling and more than a little terrifying‘.[1]

Design is more than just generating texts and images using intelligent machines, as is made possible, for example, by the increasingly powerful text-to-image software, such as DALL-E and Midjourney.[2] But such examples make it clear where the journey could also go for architecture and urban design. While physical models are still regarded as an essential medium of knowledge production, there has been an ever-widening spectrum of machine learning models for discussion for some time. A glimpse at the architecture history of digital culture makes us realize that data technologies are far too social to be understood only technically, just as societies are far too driven by data technologies to be understood only socially.[3]

The architecture history of design data literacy is a long search to find a proper culture form for the structural form of the computer. It is fundamentally about how we, as humans, want to behave towards operational technologies, and how to interact and learn with tools and machines to design buildings, explore cities and think about societies. In the twentieth century, we were primarily concerned with learning about machines; instead, we are now concerned with how to teach machines to design. This paradigm shift is accompanied by recalibrating the fundamental cultural technique of learning and interacting with tools to produce new imaginaries about the living environment and, thus, of the architect’s role as a creative communicator and explainer linking design, data and society. This change also brings new cultural, ethical, and political questions about how to rethink authorship, creativity, diversity or the digital gab in societies from a data perspective. The debate about biased training data, for example, has repeatedly shown in recent years that the humanistic ideal of learning has become a complex discourse about the power of technical intelligence on an industrial scale.[4]

The sphere of the digital has emancipated itself from being a pure history of tools machines and interfaces to a planetary narration of information networks, feedback, digital ecosystems and data economies based on machine intelligence. It is as if we need to read Marshall McLuhan’s *The Invisible Environments*, published in 1967, in the opposite direction to understand that it is now the algorithmic environments that learn something about us.

> As we move into the world of integral, computerized knowledge, mere classification becomes secondary and inadequate to the speeds with which data can now be processed. As data can be processed very rapidly we move literally into the world of pattern recognition, out of the world of mere data classification. One way of putting this is to say that our children today live in a world in which the environment itself is a teaching machine made of electric information.[5]

McLuhan suggests that digital media have the power to challenge and recalibrate existing social and cultural structures in societies. Or, as architecture historian Antoine Picon put it, our world today is ‘an heiress of the universe opened up by cybernetics and electronic art in the 1950s and 1960s‘. ‘But who would have thought,’ Picon continues, ‘that digital life would get under our skin to this degree?‘[6] It doesn’t take long to realize that this is a rhetorical question that is completely in step with our times. The radical nature of the question is already evident in the fact that even the idea of digitization creeping ‘under our skin’ is no longer a metaphor. For some time now, we have been experiencing new cultural forms of a recoding, transcoding and converting of spaces, objects, forms, surfaces, materials and the human body. We have, according to the argument behind the following reflections, become actors in a data-based world of operationality that will lead to new cultural, aesthetic, social and political design paradigms within the natural and built environment. So what does it mean to design for a data-driven society that is seeking a balance between an ecological sense of resources and artificial intelligence?

Operational Thinking

Since the mid-twentieth century, architects debated whether machines would cause severe damage to the supposedly humanistic core of design.[7] Almost unnoticed, a second intellectual battleground of entirely different dimensions developed on the peripheries of this debate, which was burgeoning, especially in the 1970s, almost ten years before the World Conference on Computers and Education in Lausanne would talk about 'computer literacy' for the first time.[8] Instead of *computer-aided design*, it was about *computer-aided instructions*, so not about the digitization of design but of learning. But this should not obscure how closely the one was coupled to the other—and still is today. What connects the datafication of design and learning is the technologization of intellectual work itself. The automation wave of the 1970s was, therefore, nothing less than a large-scale attempt to externalize and operationalize tacit knowledge and make it accessible and valuable for the societies. Digitization has not only brought about new tools, but a fundamental change in 'intellectual work' is up for debate in the future, changing design and learning. With a view to the history of digitization, two different but essentially related forms of knowledge production are thus at issue: processes of learning are, to a certain extent, also processes of designing and vice versa, whether drawing machines or learning automatons. It was about the technologization of thinking itself.

The roots of the so-called educational technology are crucial for repositioning design in the age of data. They go back to the field of 'human engineering', an interdisciplinary branch of research established at the time of the Second World War. Its goal was to optimize the interaction between humans and machines. The knowledge gained in the context of the US military was transferred to various areas: this included not only Buckminster Fuller's Dymaxion Houses[9] and Konrad Wachsmann's US Aircraft Hangar,[10] but also the automation of learning itself. Learning automata were an attempt to integrate the school as a social institution into the system competition of the Cold War, which meant not only system building and comprehensive schools, but also learning automata and cybernetic pedagogy. The catalyst for this development was the 'Sputnik shock', which grew from the awareness that the Soviet Union had gained a technological lead over the capitalist West with its successful launch of an earth-orbiting satellite in 1957.[11] The reaction of the American government was not long in coming: in 1958, only one year later, President Dwight D. Eisenhower established not only the defence institution DARPA and the space agency NASA, but also the National Defense Education Act, which entailed a large-scale reform of the American school curriculum and led to the upgrading of the technical intelligence in the country. The focus was on greater individualization of instruction and developing new kinds of interdisciplinary knowledge production. This included so-called creativity research[12] and brainstorming as well as the development of special thinktanks and 'auto-instructional programmes'. The individualization of learning led to the founding of Educational Technology, or 'edtech' for short, a new branch of research in the education industry, based in particular on the behaviourist theories of the influential psychologist and behavioural scientist B.F. Skinner.[13] Edtech promised efficiency in every respect, knowledge production and ideological protection from communist ideas. In fact, the 1960s were the golden age of the so-called teaching machines. The star of this movement was called PLATO—short for Programmed Logic for Automated Teaching Operations—and was probably the most influential teaching machine system of the post-war period. Assembled by engineers, educationalists, mathematicians and psychologists at the University of Illinois from parts of an old radar set, the new machine required the decomposition of all content into so-called 'teaching quanta' according to behaviourist theories. Content and topics were no longer to be thought out of complex contexts but sequentially and additively, as if on an assembly line. If you like, the automation of teaching went hand in hand with the automation of learning. The goal was to build a smooth control loop of learning consisting of theory, hardware, software, information and user. The focus was on creating devices that could be operated with simple buttons. In the operation of the early teaching machines, the hand was regarded as the central tool of sensory perception and haptic feedback. It is probably hardly known that Norbert Wiener, for example, also developed a special device for the deaf in 1948, one year after the publication of his epoch-making book on cybernetics. This device translated spoken language into vibration patterns that the deaf could feel with the help of tiny sensors on their fingertips and thus understand. Wiener did not develop this so-called correlator any further, but the project illustrates that the development of the early teaching machines was predominantly a question of hardware and the design of haptic human-machine communication, and that physical space played hardly any role in this. This changed with the beginning of new network technologies. Instead of just individual places, it was now about global systems, networked thinking and communication environments. Architects rediscovered the physical space, not to design it, but to overcome it.

From Places to Networks

McLuhan's vision about the disruptive potential of electronic media on education developed into an equivalent debate about space and new communication technologies. In the late 1960s several architects, including Toyo Ito, Buckminster Fuller, Yona Friedman and Constantin Doxiadis, began to interpret the building not as a single object, but as a global network of virtual nodes. Swiss architect Fritz Haller, for instance, had realized a series of innovative school and university buildings since the 1950s and was also known for his USM Haller building systems and the USM Haller furniture system.[14] For the competition for a new university campus for the École Polytechnique Fédérale de Lausanne (EPFL), he submitted a project that attempted to leap from an architectural building system to a technological communication system. According to Haller, a university is no longer an autonomous institution but a node in a worldwide knowledge network linked by telephone, television, data interconnection and high-speed trains. Added to this is the idea that universities are no longer limited to academic discourse but radiate into society as 'cultural centres'. This network thinking was the highlight of the project. Haller, who had visited the recently completed university buildings in West Germany for the competition, developed a speculative scheme of how the spaces of learning would develop in the future. According to Haller, the 'general transformation trend' of school models will develop in four stages: from the traditional hierarchizing model to an ever-flatter hierarchy. First, the head teachers will disappear and then the teachers; then classical frontal teaching will be replaced by dynamic forms of community and team teaching. In the fourth and final stage, the school is a network of interdisciplinary learning made up of nodes. Specific types of space are assigned to the different levels under the heading 'Building Structure'. The first three levels can be brought into line with examples of Haller's school buildings, such as the Höhere Technische Lehranstalt Brugg-Windisch (1961–1966). In the last level, he proposes an open-plan school as a system open on all sides, with separable rooms, depending on the visual, acoustic and climatic requirements of teaching. But by the end of the 1970s, the time for visionary school-building projects seemed to have finally run out. And so Haller's network university was not awarded a prize. The competition jury found the vision too radical and not sufficiently application-oriented. Haller expressed his disappointment to the Studiengruppe für Systemforschung (Study Group for Systems Research), co-founded by Horst Rittel, a mathematician and former teacher at Ulm School of Design: 'The experts called the work interesting, but too progressive—too inhuman—too un-architectural. Maybe later on, you can build something like that.'[15] Haller held on to the idea of expanding spaces of learning through communication technologies. In 1996, only a few years after the foundations of the modern World Wide Web were laid at the European Organisation for Nuclear Research (CERN), Haller was also sure: 'Schools will no longer be schools. They will be communication nodes of a global network of relationships and data, in which people of all levels of knowledge and rank will act within their possibilities and create new values.'[16]

What Haller describes here as a vision for education would later become the basis of a platform-based data economy. His idea of open networks and knowledge societies builds on concepts developed since the 1970s. In particular, Daniel Bell's *The Coming of Post-Industrial Society*,[17] published in 1974, laid the foundation for our current discussion on the spatial impact of platforms and logistics on the built environment.

From Instructions to Discovery

In 1970, the same year Haller submitted his entry for the EPFL competition, Marshall McLuhan published an essay titled 'Education in the Electronic Age', with which he arguably created one of the most influential blueprints for the digital culture of learning. The division into chairs, according to McLuhan, also belonged to the dissecting and specializing age of printing, a time still without feedback. McLuhan said that anyone could learn about anything on their own if they were given encouragement and tools. And this is precisely where the utopian potential of the early digital tool culture lies. So, it was educational issues that decided the future of computers and societies, from the earlier teaching machines to Fritz Haller's global university networks. McLuhan was convinced that you could transform learning if you transformed the spaces of learning. Modern communication technologies could even liberate societies from the rigid thought patterns of school institutions so that, in the end, they would practically no longer be needed. Technology's reform potential was no longer located in schools, but in the outside space, cities and the environment. It is no coincidence that McLuhan spoke of 'classrooms without walls', a wonderful metaphor that could also be used as a proxy for the countless experimental places of learning in the digital age.

> The changes have gone on outside, not inside the school. The outside environment, perhaps for the first time in history, is, in terms of information, many times more heavily laden than the inside environment of the school. What is going on inside the school is puny and nourished compared to what goes on the moment the child steps outside ... What goes on inside the school is an interruption of education, of the education available in the current environment. In the electric age, people make their world in an entirely new way; the whole environment is created.[18]

McLuhan tried to overcome schools as institutional and built spaces, which may have been because he saw in the mass media, and especially in communication technologies, a new kind of global feedback infrastructure for unfolding independent and individual learning. Education in the electronic age was a matter of discovery and exploration.

From Miniaturization to Ecosystems

Haller's network architecture and McLuhan's vision of education must be seen in the context of another debate. In the 1960s, much revolved around digitizing basic cultural techniques, such as writing, arithmetic or reading, which meant reading, writing or calculating and drawing. Thin graphic lines flickered on architects' screens initially introduced by the military industry (ARPA), and the traditional coupling of drawing and seeing, as well as seeing, was scrutinized by a new kind of computational knowledge. The intuitive dialogue between the hand and the creative eye was thus severely disrupted. Drawing is linked to design and, accordingly, to thinking, and many architects feared the automation of one also meant the automation of the other. Machine intelligence, therefore, seemed to be about a double cultural devaluation: that of the architect as the sole decisionmaker and that of the design process as a creative genius technique. This was prompted by new digital infrastructures as well as machine storage, processing and communication.

The early computer avant-garde understood that you had to focus on people's behaviour and therefore also on their mental schematic. Influential figures such as Steven Coons laid the conceptual foundation for a machine world in which the mathematical control of abstract input and output variables rather than the mechanics of the physical object could be regarded as the characteristics of a machine. The boundaries between man and machine, nature and culture were to be overcome in order to arrive at a new kind of behaviourist machine thinking and finally at a superordinate method of algorithmic world analysis.

Exemplary for such a behaviourist view was Augmenting Human Intellect, a human–machine theory developed by electrical engineer Douglas Engelbart. He believed computers could expand the cognitive abilities of humans, and designed a remarkable vision of the future for the architect. With the sentence 'Let us consider an augmented architect at work',[19] he began to describe the working process of a computer-aided architect. This 'augmented architect'[20] was to have a screen and a small keyboard at his workplace, which he could use to communicate with the machine. 'With a "pointer", he [the architect] indicates two points of interest, moves his left hand rapidly over the keyboard, and the distance and elevation between the points indicated appear on the right-hand third of the screen.'[21] It is possible to rotate a drawing constructed in this way. Using the keyboard, the architect can also enter metric data. After several steps, the first outlines of the building would emerge. At the same time, the mechanical architecture assistant calculated the possible effects of the designed building and tested them under different parameters. All the data produced in the course of such a working process—which, interestingly enough, Engelbart understood to mean not only 'the building design' but also 'its associated thought structure'—could ultimately be saved on a 'tape' and retrieved at any time.

With Marshall McLuhan, we could say that Engelbart understood computers as a creative prosthesis, that is, an extension by means of which the architect's cognitive and physical abilities can be extended and technically enhanced.

The term ‘augmented architect’ makes it clear that the architect should be woven into an information technology milieu and that the digital should be wrapped around him like a second skin. The architect's drawing table was transformed into a digital ecosystem of interfaces, tools and databases.

Towards Design in Open Data Societies

The image of the future is by no means just a question of data—although in many ways it is. Today, almost 50 years after McLuhans *invisible environments*, Bell's *post-industrial society* and the dazzling wave of cyberneticization of learning, and designing, modern forms of societies have emerged that could perhaps best be described as ‘delivery societies’ or ‘cloud economies‘, linking people and buildings to platforms, interfaces, data centres and machine intelligence. Data is no longer just traded like an important raw material. It also forms the economic basis of perhaps the most powerful promise of a predictable future. French philosopher Cornelius Castoriadis claimed that ‘no category apart from the *imaginary* allows us to reflect on the idea of society‘.[22] This is an appealing and clever assertion, as it gets to the heart of something that seldom attracts much attention, that is that we are constantly searching for new models of community and living together. This is no longer about the conscious fusion of aesthetics and life, however, as was so vehemently demanded by the artistic avant-garde movements of the last century. Rather, it seems, a new kind of data-based reading of the entire environment is up for debate. Whether bodies, buildings, cities, landscapes, oceans or climate, we are at the beginning of a large-scale operationalization project in which, in terms of media technology, there is no longer an inside or an outside and whose goal is nothing less than a planetary rereading. In other words: the computerization of the world makes us realize what it means to be part of a globally operating industrial complex. This is especially true for architectural production. Materials, objects and capital circulate in an infrastructural matrix whose scale and impact we are only gradually beginning to understand. Thanks to more precise simulation models of material and substance cycles, we are increasingly able to document and research the consequences of an environment that has been completely transformed by humans. Digital mappings are now emerging that will lead to new insights and simultaneously question traditional supply and production systems. We are only beginning to grasp, for example, that the *way* buildings are manufactured and constructed around the world is a process that no longer takes place only on the Earth's surface, but also leaves traces deep inside it. Copper and lithium are mined and processed for the global construction industry. Even the ocean has changed from a once mythical place into a vast geopolitical infrastructure project, whose story can no longer be told without oil platforms, undersea cables, floating server farms and forensic oceanography.

How can construction, raw materials and digitization be brought together in the future? And what is actually the geological footprint of future data-based digital architectural production? These are tricky but nonetheless important questions that are not only about innovation, but also about responsibility, and in the coming decades they will certainly have a greater impact on construction than we may have expected. The twenty-first century will require us to design in an open-data-based and ecological way, which is nothing less than developing design data literacy for the age of machine intelligence. The question of what it means to design in such societies, or even how we can produce meaning at all from the vast amounts of environmental data, is the other side. In the future, we will not be able to avoid computer vision and machine learning, because human intuition will eventually reach its natural limits when faced with so much data. We are collecting more and more data about materials, the environment and the climate, but the faster this data is collected, the more likely we are to be confronted with the limitations of our own ability to make judgements. We will have to admit to ourselves that we will neither be able to evaluate nor judge the complex structure of open-data societies without automated analytical capabilities.

Instead of purely technical aspects, today's focus is increasingly on social, ecological and ethical aspects of platform technologies, such as the digital divide, privacy, ownership, accessibility, sustainability and public trust in clean and qualitative architectural datasets. These issues form perhaps one of the most significant architectural challenges in the coming decade, aiming to sovereignly position and critically examine the creative, social and political potential of operational design thinking in open data societies.

Notes

[1] Farhad Manjoo, ‘How Do You Know a Human Wrote This?‘, *New York Times*, 29 July 2020, https://www.nytimes.com/2020/07/29/opinion/gpt-3-ai-automation.html, accessed 26 November 2022.

[2] See: Matthew Mullane, ‘Seeing History with Computer Vision: The Architecture of Text-to-Image Synthesis‘, and Erik Hermann, ‘Mambo Dogface to the Banana Patch? Talking Wrong with Deep Learning‘, both papers presented at the 9th Jaap Bakema Study Centre conference on ‘Building Data. Architecture, Memory, and Imaginaries‘, 23 November 2022.

[3] See: Georg Vrachliotis, *The New Technological Condition: Architecture and Design in the Age of Cybernetic* (Basel: Birkhäuser, 2022).

[4] See: Safiya Umoja Noble: *Algorithms of Oppression: How Search Engines Reinforce Racism* (New York: NYU Press, 2018).

[5] Marshall McLuhan, ‘The Invisible Environment: The Future of an Erosion‘, *Perspecta* 11 (1967), 161–167.

[6] Antoine Picon, ‘Architektur und Wissenschaft: Wissenschaftliche Exaktheit oder produktives Missverständnis?’, in: Ákos Morávanszky and Ole W. Fischer (eds.), *Precisions: Architektur zwischen Wissenschaft und Kunst* (Berlin: JOVIS, 2008), 78.

[7] See: Georg Vrachliotis, ‘Architecture, Computer and Technological Unrest: Towards an Architecture History of Anxiety‘, in: Teresa Fankhänel and Andres Lepik, *The Architecture Machine: The Role of Computers in Architecture* (Basel: Birkhäuser, 2020), 28–34.

[8] Computers in Education: Proceedings of the IFIP TC-3 3rd World Conference on Computers in Education, Lausanne, 27–31 July 1981.

[9] See: Federico Neder, Elsa Lam and Mark Wigley, *Fuller Houses: R. Buckminster Fuller's Dymaxion Dwellings and Other Domestic Adventures* (Baden: Müller, 2008).

[10] See: Konrad Wachsmann, *The Turning Point of Building: Structure and Design* (New York: Reinhold, 1961); and Georg Vrachliotis, ‘Konrad Wachsmann's Educational Concepts’, in: Beatriz Colomina et al. (eds.), *Radical Pedagogies* (Cambridge, MA: MIT Press, 2022).

[11] See: Barbara Barksdale Clowse: *Brainpower For The Cold War: The Sputnik Crisis and National Defense Education Act of 1958* (Westport: Greenwood Press, 1981).

[12] See: Bregje F. van Eekelen, ‘Uncle Sam Needs Your Ideas: A Brief History of Embodied Knowledge in American World War II Posters‘, *Public Culture* 30/1 (2018), 113, 1527–8018.

[13] B.F. Skinner, *The Technology of Teaching* (New York: Appleton-Century-Crofts, 1968).

[14] See: Laurent Stalder and Georg Vrachliotis (eds.), *Fritz Haller: Architekt und Forscher* (Zurich: gta Verlag, 2015).

[15] Fritz Haller, Letter to Thorbjörn Mann, 16 July 1970; gta Archive, ETH Zurich: Fritz Haller Archive, file 189–0316.

[16] Fritz Haller, 1996; gta Archive, ETH Zürich: Fritz Haller Archive,

[17] Daniel Bell, *The Coming of Post-Industrial Society* (New York: Harper Colophon Books, 1974).

[18] Marshall McLuhan: “Education in the Electronic Age”, in: *Interchange* 1/4 (1970), p 1

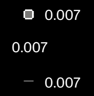
[19] Douglas C. Engelbart, ‘Augmenting Human Intellect: A Conceptual Framework’, Summary Report AFOSR-3223 prepared for the Air Force Office of Scientific Research, Stanford Research Institute, Menlo Park, CA, October 1962, 1.

[20] Ibid., 4.

[21] Ibid.

[22] Cornelius Castoriadis, *Gesellschaft als imaginäre Institution: Entwurf einer politischen Philosophie* (Frankfurt am Main: Suhrkamp, 1990), 274.

BACTERIA



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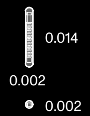

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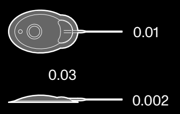

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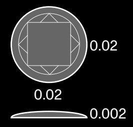

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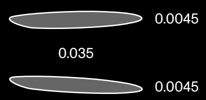

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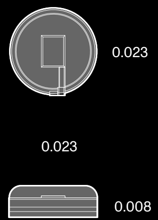

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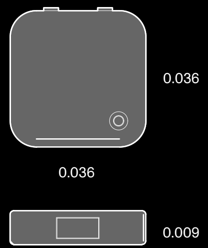

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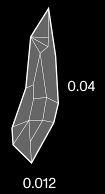

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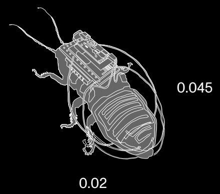

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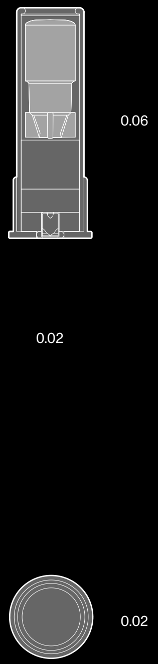

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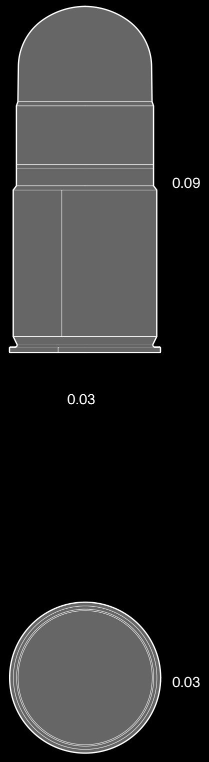

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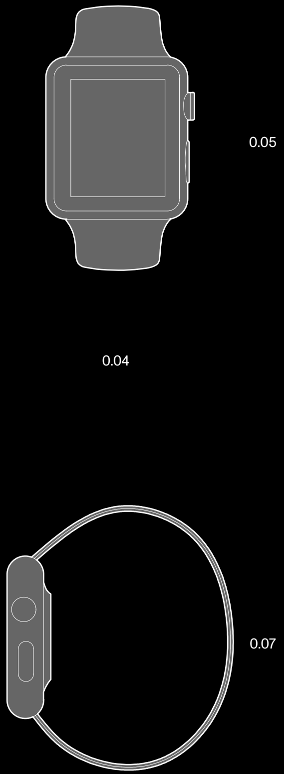
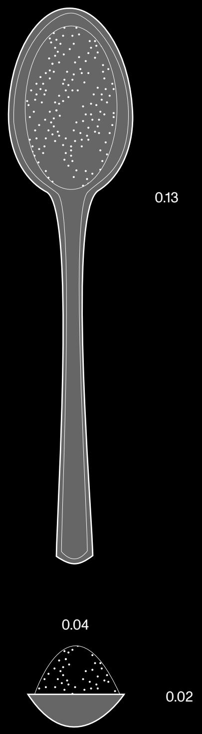


SMART WATCH



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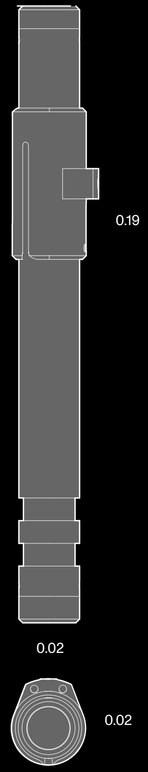

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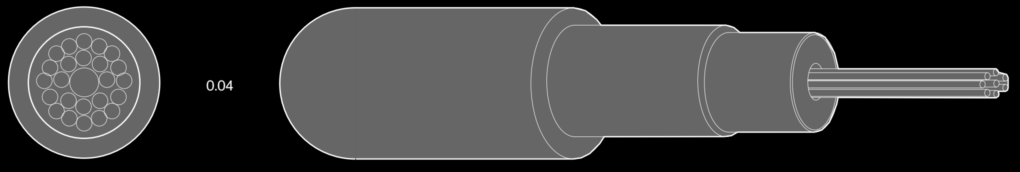
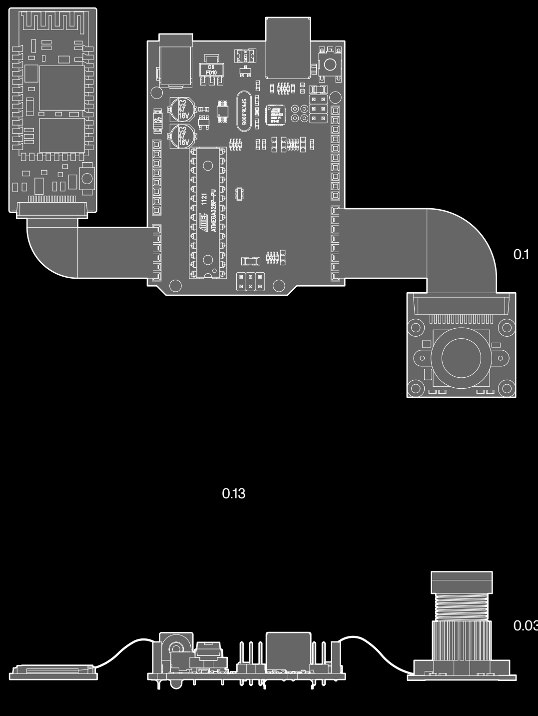
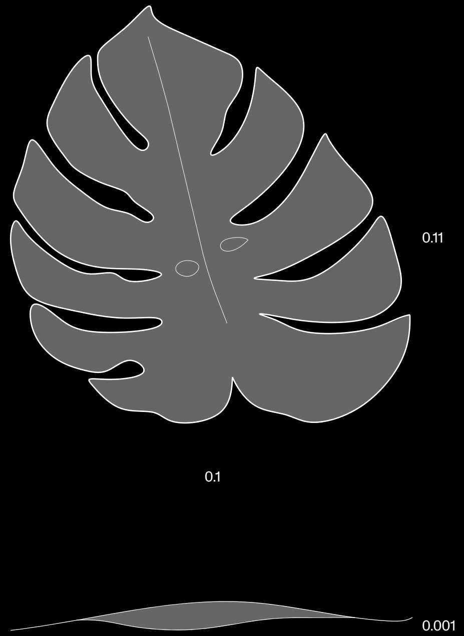


LIGHTWEIGHT SUBMARINE CABLE



ARDUINO WITH BLUETOOTH AND CAMERA MODULE



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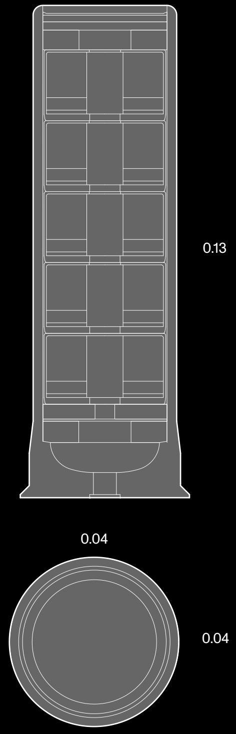

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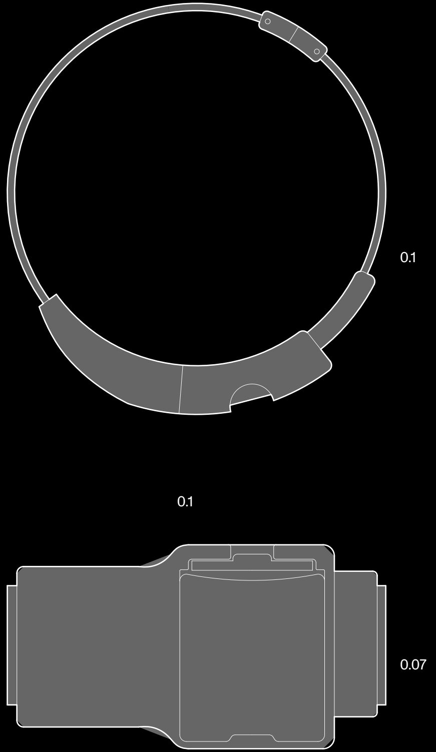

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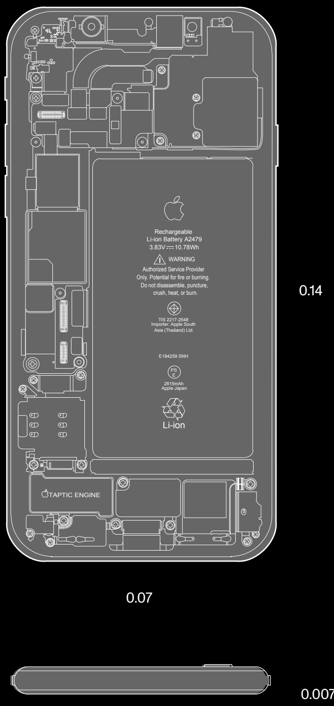

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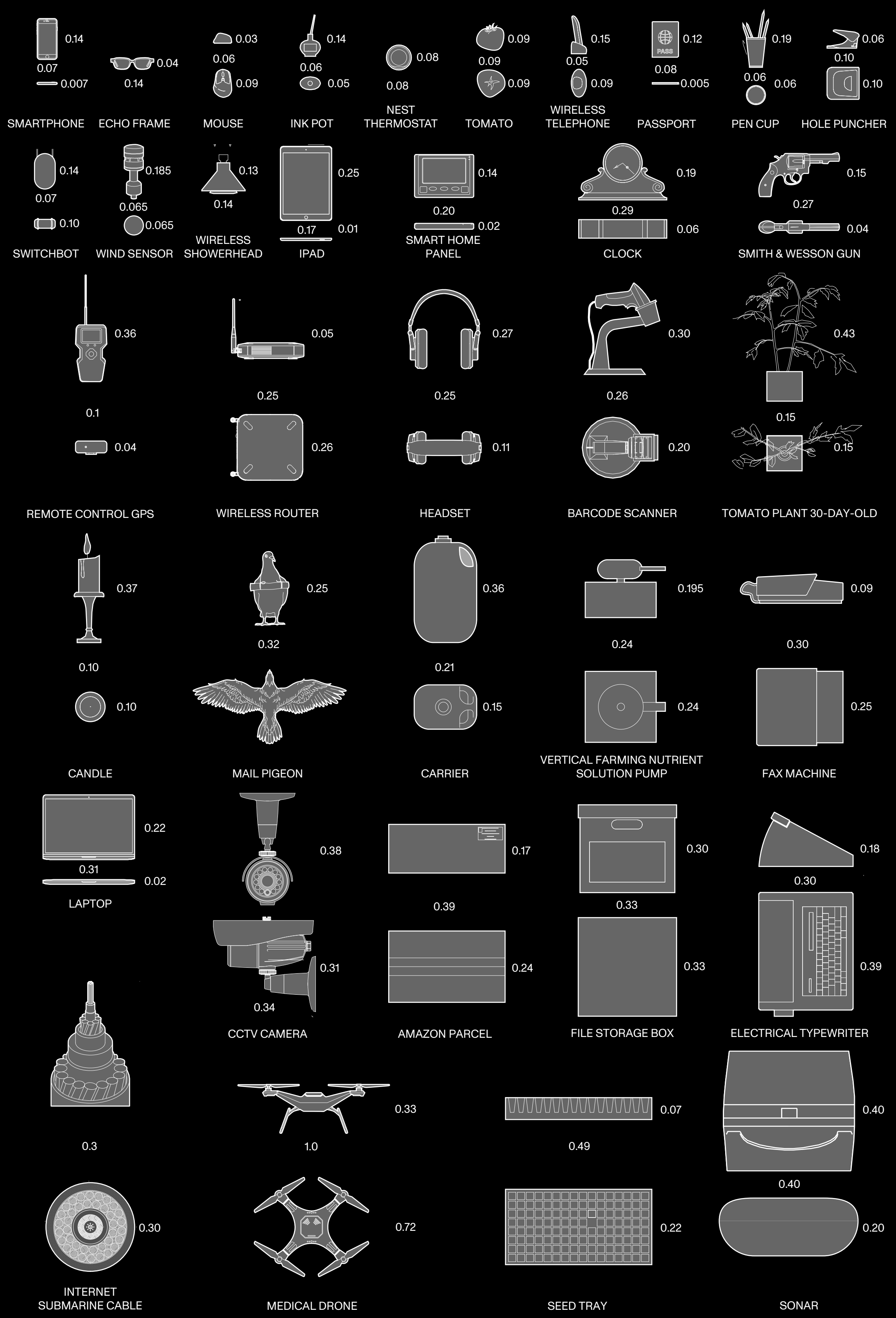
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TOMATO
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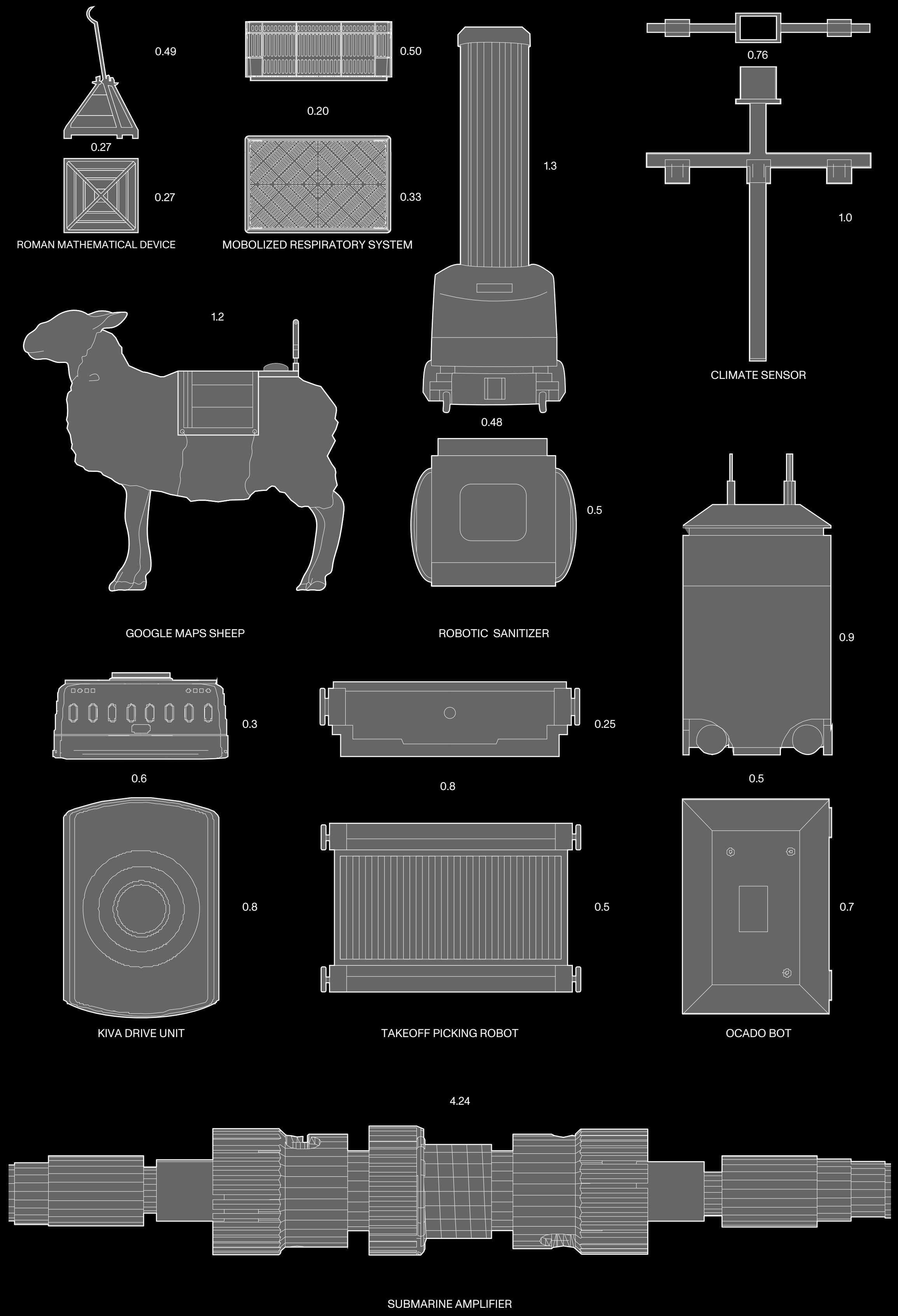
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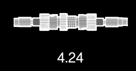
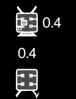


SUBMARINE AMPLIFIER

PALLET



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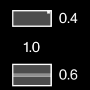

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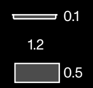
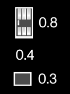


GROWING TRAY

BARRICADE



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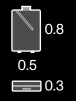

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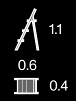

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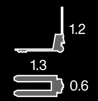
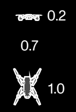


PALLET JACK

UMBRELA



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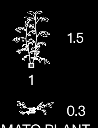

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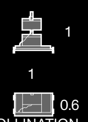
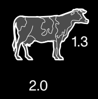
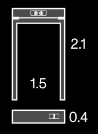


POLLINATION MACHINE

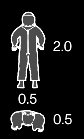
SEGWAY



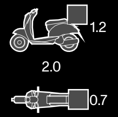
COW



BODY SCANNER



SPACE SUIT



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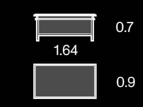

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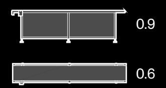
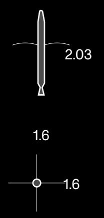


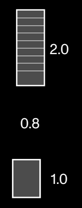
FLAT BELT CONVEYOR



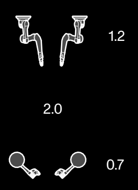
EXPLORER 1 SATELITTE

PRINTER

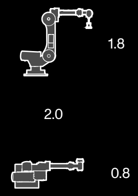
TERMINAL EQUIPMENT



SERVER RACK



ROBOTIC ARM



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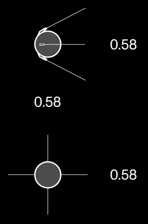

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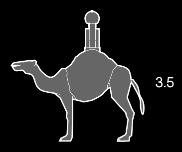

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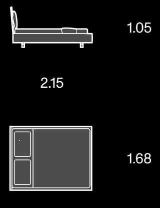

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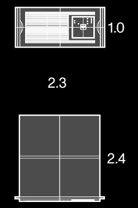
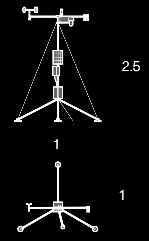
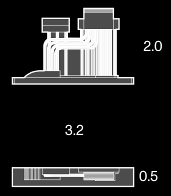


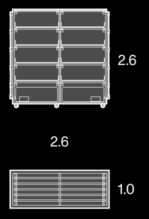
BATTERY PACK



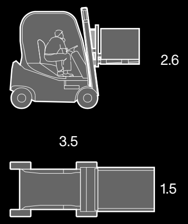
AUTOMATIC MOBILE WEATHER STATION



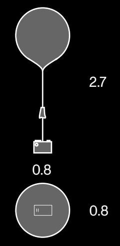
ROOM REGULATOR



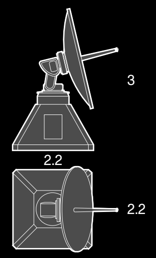
VERTICAL FARMING GROWING RACKS



FORKLIFT



WEATHER BALLOON



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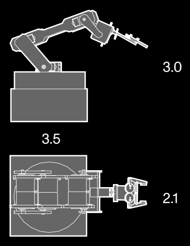
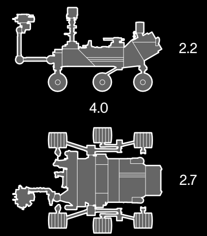
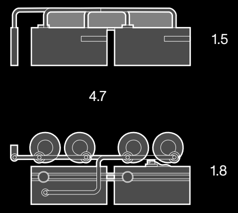


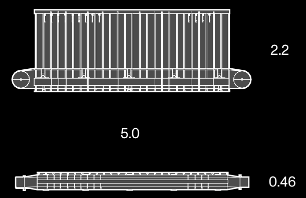
ROBO STOW ARM



CURIOSITY ROVER

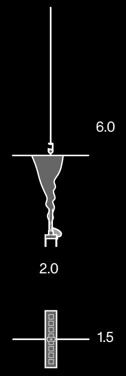


WATER FILTER UNIT

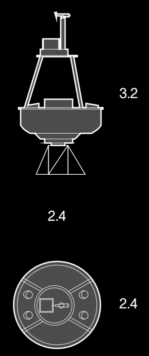


UV SANITIZER CLOSET WITH CONVEYOR BELT

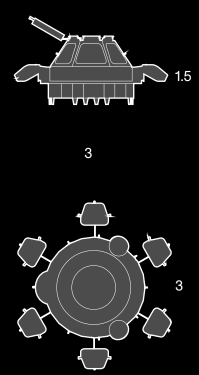
OBSERVATION TOWER



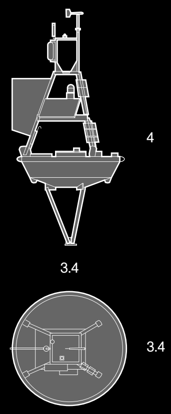
GROWING AREA RACKS



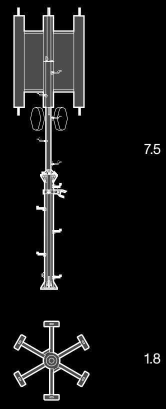
COASTAL WEATHER BUOY



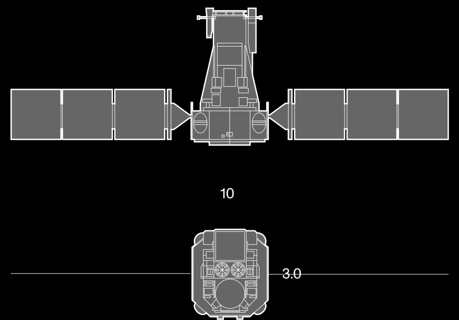
ISS CUPOLA



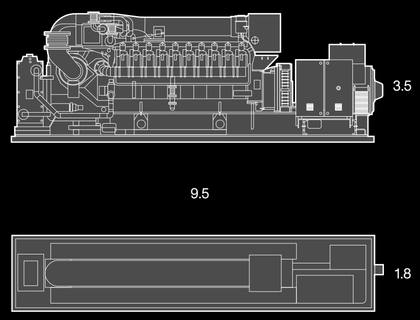
NOMAD WEATHER BUOY



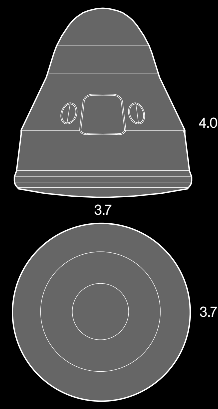
5G ANTENNA



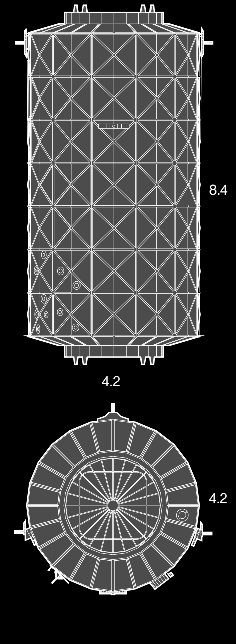
GEOSTATIONARY ORBIT SATELLITE



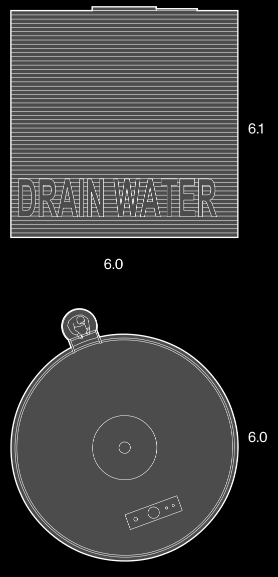
COMBINED HEATING AND POWER UNIT



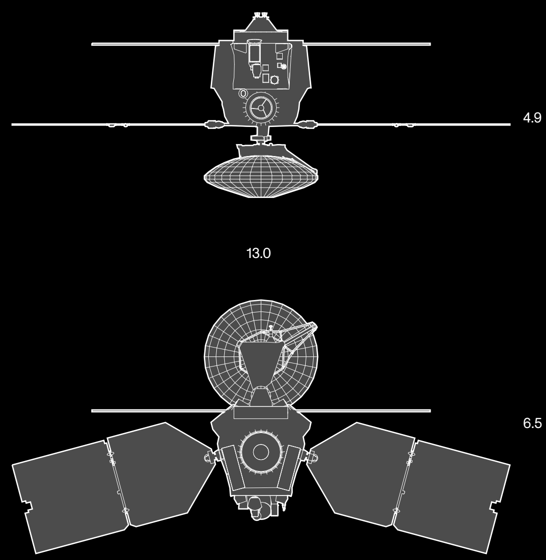
SPACE X'S CREW GRADON SPACECRAFT



ISS DESTINY MODULE (US LAB)

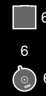


DRAIN WATER TANK



MARS RECONNAISSANCE ROVER

MARS RECONNAIS-SANCE ROVER



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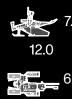
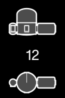
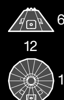


SEA PLOUGH

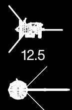
SEMITRAILER



DEEP SPACE HABITAT

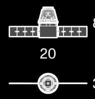


ESA CREW MODULE

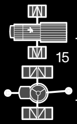


SATELLITE

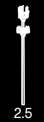
AIRPLANE



SPACE X DRAGON

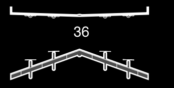


HUBBLE TELESCOPE

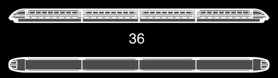


ROAD BASE STATION UNIT

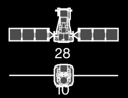
MILITARY DRONE



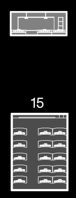
FACEBOOK AQUILA—SOLAR POWERED DRONE



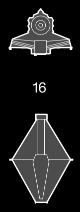
TRAIN



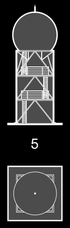
GEOSTATIONARY ORBIT SATELLITE



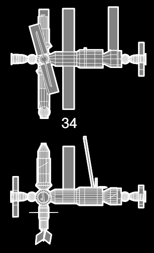
MISSION CONTROL CENTRE



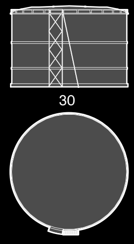
JAMES WEBB TELESCOPE



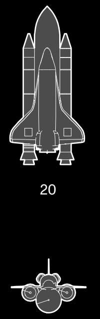
DOPPLER RADAR TOWER



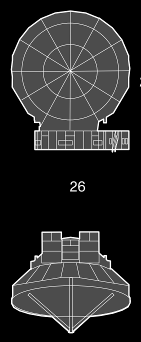
MIR SPACE STATION



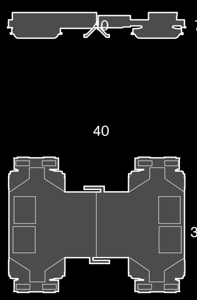
PEM ELECTROLYSIS TANK



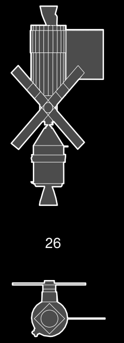
NASA SPACE SHUTTLE



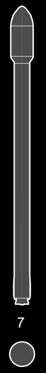
ANTENNA ONE DISH



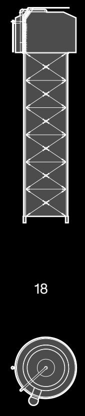
CRAWLER-TRANSPORTER



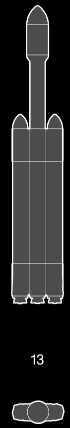
SKYLAB



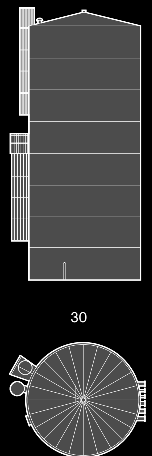
FALCON 9



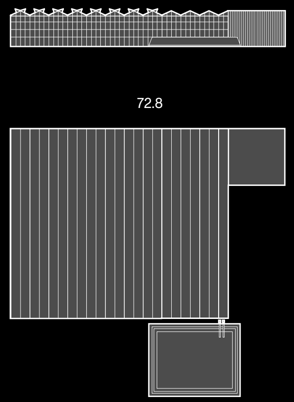
WATER STORAGE TOWER



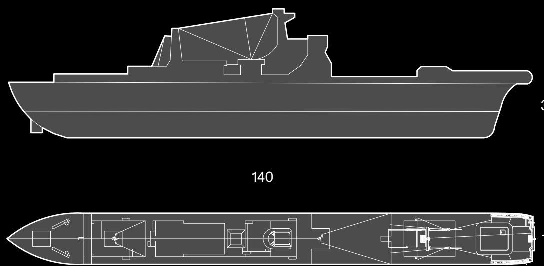
FALCON HEAVY



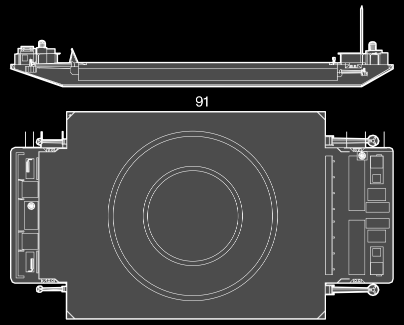
WATER STORAGE TANK



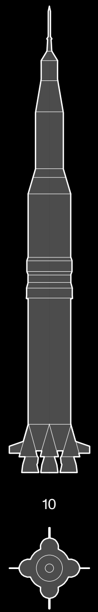
FULLY AUTOMATED TOMATO GREENHOUSE



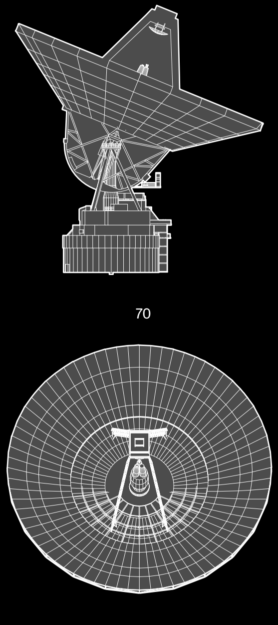
CABLE LAYING SHIP



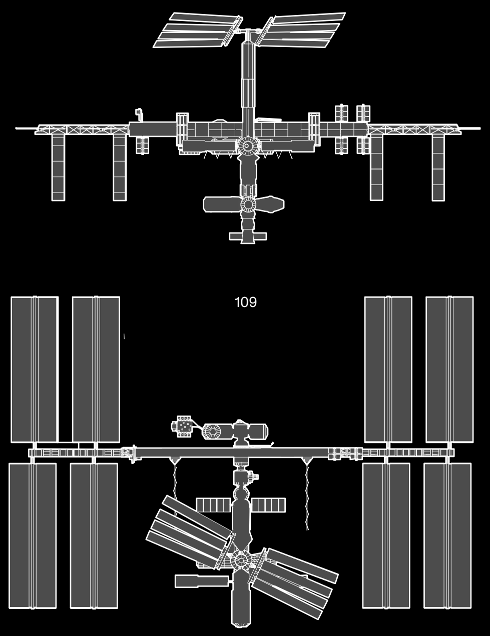
AUTONOMOUS SPACEPORT DRONE SHIP



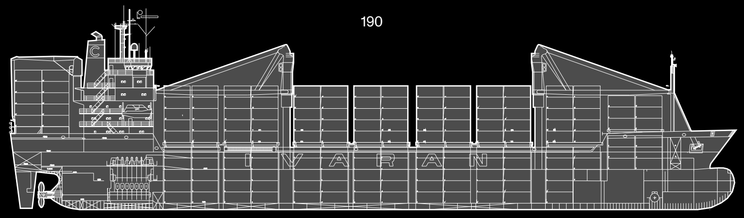
SATURN V



DEEP SPACE NETWORK ANTENNA



INTERNATIONAL SPACE STATION



CARGO SHIP

ON GIZMOS, GADGETS,

ON GIZMOS, GADGETS, OBJECTS AND DATA

Kees Kaan

The curators of this wonderful publication asked me to reflect on the gizmo catalogue, a fantastic section of the book. It features a range of objects, from astronaut suits and spacecrafts to pens and printers, beautifully drawn in scales 1:200, 1:200 or 1:20, and 1:2, with top and side views. Any reflection on data, AI, new technology versus proven technology, or the transition from analogue to digital generally raises more questions than answers. My contribution to this book does the same.

Datapolis investigates the data revolution's impact on humans and our physical environment. What is the effect of the ostensibly ephemeral cloud that hosts the virtual world? How does it influence our habits, behaviour and the things we surround ourselves with?

We have built an immense physical infrastructure, apparently invisible, hiding in the countryside, oceans and desolate places, to perpetuate the myth of people and things being wirelessly connected. *Datapolis* unmasks the cloud and exposes its physical impact. City and countryside are changing due to the disruptive effect of the 'delivery society' we are creating, whether it concerns bringing food, clothing, energy or ideas to our homes. Every wish is fulfilled at the touch of a button. But at what cost? How does this translate into a design brief or building requirements? What will be radically different in future buildings, and what will stay the same?

Simply put, what is the physical impact of data? This question is critical to architecture, a slow profession by nature. Buildings facilitate societal change and reflect them once they have already been crystallized. Architecture is a result rather than a driver of change, consolidating instead of initiating it. This means that we are now gazing at the immense complexes that the new technology sector generates. As the semiconductor is reduced to the nanoscale, getting smaller and smaller, data centres, production facilities, offices and warehouses produce giant structures devoid of people.

Datapolis's catalogue of gizmos is an overview of instruments, tools, means of transport or communication. These objects are time-bound and testify to human ambitions and expectations. They tell the story of the birth and rise of the new tech era, witnessing the innocence of the first computer and spacecraft to the swell of the current wave of change. They are also designed objects.

Museums worldwide exhibit artefacts related to food, work, war and domesticity that tell us something about the culture that produced and used them. We are interested in stuff that helps us understand our culture and, ultimately ourselves. Coins, jugs, tools, weapons and works of art are silent witnesses of humanity.

Humans surround themselves with objects. We find them in the layers of soil, but also orbiting the globe. The gizmos are a vestige of our development, and that wave swells exponentially. The objects we make are designed not just around our bodies, but for abstract activities, including required furniture, equipment and tools. Humans stay more or less the same in their basic needs and requirements, physical proportions, strength and weaknesses; the change is evolutionary and slow. But as the performance level of buildings towards the body rises, demanding higher comfort, safety and wellbeing, the gizmos change much quicker. Our buildings and cities transform while our bodies stay the same.

Not only do people surround themselves with stuff, they also drag it into their buildings. A functional office is a building where you can set up desks and chairs or distribute conference tables properly. A functional building is not just made according to the human body, but according to the logic of the tools it uses and all its surrounding processes and requirements.

The new connected world causes a considerable shift in those work and life processes and the gizmos that come with it. Today's body has acquired a set of personal tools. Processes and tools are increasingly pointing towards the self and the I. Steve Jobs saw it clearly—gizmos must become personalized tools merged with our identity. Maybe this is a first step towards integrating the body with the gizmo. The I-tool is a step towards the cyborg.

To optimally facilitate the workings of those small personal gadgets, the tech sector is building ample facilities in rural and industrial areas and hiding infrastructure in oceans and space. The freedom of the influencer in the city is facilitated by giant complexes in the hinterland, -sea and -space. There is an unstoppable simultaneous process of shrinking to nanotools and growing to megacomplexes. Both are subject to permanent innovation and either scaling up or downsizing radically.

Architects keep their eyes on the scale of 20 to 200, and the in-between where we try to maintain our precious cities and rural areas because that is where we live. It is our habitat that these new giants should not invade. The middle scale (normal buildings) is still developing in a noncommittal formalism. Exciting, iconic buildings, which are actually immensely boring non-exciting inventions, must disguise the fact that mid-scale development lags behind the two extremes. At this level, the radical urgency that characterizes new tech infrastructures has so far been lacking, or people are obsessively holding on to what they have because it's their core habitat, a place of comfort and joy—it is a gigantic dichotomy that is becoming a real issue.

Meanwhile, the city as we are used to it is gradually becoming untenable. The comfort and joy are not sustainable, the energy is inefficient, the waste is piling up and the food production is out of balance. There is a crisis because the city and the hinterland, mutually dependent, are out of balance.

Here we are, working and living in high-density areas, in buildings overcrowded with bodies and mobile devices served from empty buildings elsewhere buzzing with installations. We were able to manage the pandemic thanks to these virtual connections facilitated from those large empty buildings. We could largely continue our societal necessities, despite the personal physical isolation that the lockdown forced on us.

Is this a step towards a metaverse that will generally give some relief to the physical world? *Datapolis* does not yet indicate a development in that direction; the people's physical world and the footprint created are still expanding. But our built environment is our daily habitat. It is shaped by people over time and continuously changes and updates through complex processes driven by societal, economic, political and technical forces. In this setup, the role of design is crucial. Keeping in mind the best interest of society and human life, one could assume that if more accurate, complete and unbiased information is available in this ongoing process, our ability to shape our habitat will be better too. If this assumption is correct, then open data—impartial and fair—is essential.

This was my answer when Georg Vrachliotis invited me to The New Open conference on 27 and 28 October 2022. Tech is causing unmanageable, potentially ruinous disruptions and scale wrinkles in the built environment, but now we must also assume that it will help us fix those problems? Is the very industrial complex that is magnifying the problems also the key to solving them?

That is why I have added: 'If this assumption is correct.' The next step could be that the built environment gradually becomes more interactive, anticipating and performative. This performative environment, with its inhabitants, humans or other forms of life in all their diversities, might constitute a new cyber intelligence. Sounds like science fiction.

When it comes to design, we are guided by our values. They are in a permanent state of change while we, as a society, try to figure out what works and what needs to be updated. This means that design is evolutionary, but if so—do we also keep making the same mistakes?

Is knowledge built upon big data a guarantee for better solutions for real-world problems, or could it also generate huge collective mistakes?

While I'm thinking about the gizmos in this book, an e-invitation to participate in the event of Communities of Tacit Knowledge drops in my mailbox. The community investigates Architecture and Its Ways of Knowing and is organizing an exhibition and debate on the Object. They're asking me to choose an object that, for me, exemplifies the way tacit knowledge operates in architecture. Tacit is such an abstract concept. Bringing it to the surface and making it visible and tangible through objects could be a method to understand architecture better and find out where specific knowledge is hiding.

I wonder if tacit knowledge might be the opposite of artificial intelligence. Or are they just different forms of knowledge? Tacit knowledge is unspoken knowledge that allows us to do or know things without understanding why and how we got that ability. Kind of like riding a bicycle.

Artificial intelligence is the man-made ability of machines to learn and apply knowledge. Would a machine be able to deploy tacit knowledge? Can the machine do or know something without first knowing the why and how?

This is a question for one of our AI scientists, so I decided to talk to Seyran Khademi, the director of the AI lab in our department. It seemed only fitting to do it through a gizmo in WhatsApp.

KK Do you think a machine can develop tacit knowledge?
SK I think the challenge with tacit knowledge is transferring it to other humans. So even if a machine could generate it, I would not know how to visualize/represent it, so basically, how to show it.
KK Well, I understood that it is knowledge or ability that we cannot trace back to its origin; we cannot explain precisely how it works, like riding a bike.
SK That is exactly how AI learns from data, but I doubt it can transfer tacit knowledge to explicit knowledge. AI learns from data because we cannot explicitly program computers to do complex tasks like vision (or riding a bike) :)

She says that computer scientists don't know how to write a program to make a computer visually recognize a cat just by seeing it. They can repeatedly show a million or more images of a cat to the machine. The machine will, from now on, recognize a cat by comparing the data. Next, the machine cannot recognize a dog and needs to see a million images of dogs. That doesn't sound very 'intelligent', does it?

It brings me back to the question. If we knew all there is to know, if all existing human knowledge built up over thousands of years would be broken down into data and become accessible for AI, would it prevent us from making the same eternal mistakes?

KK then you are saying that AI is a form of tacit knowledge.
SK I would say tacit information. The knowledge still needs to be extracted.

Then I bring it forward—the big question:

KK Do you think AI could also lead to big collective mistakes because it uses data that was implicitly extracted from human errors, tacit mistakes?
SK that is a very hot research topic.
SK for sure, it can magnify our mistakes for the worse.
KK so many scientists are on this topic
SK yes.

A couple of days later I ask Seyran permission to use the conversation for this contribution to *Datapolis*. So, I send her the complete written text above.

SK Also, there is a question the interviewer asks I suppose, and I quote: 'She says that computer scientists don't know how to write a program to make a computer visually recognize a cat just by seeing it. They can repeatedly show a million or more images of a cat to the machine. The machine will, from now on, recognize a cat by comparing the data. Next, the machine cannot recognize a dog and needs to see a million images of dogs. That doesn't sound very 'intelligent', does it?"

The answer is: What do you consider intelligence? If we assume that humans are intelligent then this is how our brain learns. If a kid did not see a dog before, she would not recognize it. We as intelligent species learn to perceive our world using our biological sensors, modern AI borrows the same process, however, AI 'perceives' the digital world abstracted in the data.

Call me if you have any other questions. So, I did call her by mail.

KK Great Seyran, I will work it in the text. Of course, humans must also learn everything piece by piece, bit by bit, but do children learn quicker (with fewer examples) than machines or do machines also more quickly learn quicker the dog after having learned the cat?
KK sorry for bothering you with these questions...
SK My favourite questions :)

Yes that is true and our machines are still an infant in that sense, the human brain is able to do multitask learning, e.g., knowing German makes it easier to learn Dutch. Also, we are better at generalizing unseen examples, seeing a dog for the first time, a kid can categorize it as an animal or even a pet.

Many researchers are also working on multitask learning in AI, inspired by how our brain works again by learning from data (data-driven) rather than explicit algorithms (knowledge-driven). However, machines are scalable in terms of processing power so analysing lots of data, unlike the human brain, which has not changed much in thousand years.

Epilogue

This conversation opens so many doors to new questions. The new AI program that was initiated by Delft University of Technology is very exciting. I feel privileged to be able to work with all these brains.

Today we need to cope with a lot of information while designing, and if we want it to be state of the art, pure humanistic design talent is no longer enough. Of course experience is important, but we need to access new layers of information/knowledge simultaneously. We might come closer to the actual concept of a 'knowledge of everything' by connecting many brains to generate a new collective knowing. Connecting brains requires ultra-clear lines of communication and exchange of information. I have a hunch that new technologies, big data and AI are based on universal templates. Using those could prove beneficial to this improved communication and collaboration of brains. Design research collaboration between practitioners and academics could establish new models of collecting information and designing.

If humans have a future on this planet, we need to change how we deal with our built environment; we cannot continue to rely on the interventions of individual geniuses. We need a collective effort and all the knowledge in the world to achieve higher standards and better results.

We must change our way of working as architects, not our way of being architects.

Glossary

Gizmo	A gadget, especially one whose real name and use has been forgotten. It's a weird kind of gadget.
Gadget	A small technological or mechanical object, innovative and appealing, a wanna-have.
Object	A material thing that can be seen and touched. A person to whom a certain action is specified.
Design object	An expressed solution to a real-world problem.
Ready-made	A mass-produced object displayed as a work of art.
Objective	A concept of truth independent from individual subjectivity. Without need for interpretation.
Subject	A thing or person being discussed or described
Subjective	Based on or influenced by.
Tacit	Understood or implied without being stated.
Implicit	Suggested but not directly expressed.
Explicit	Stated clearly and in detail, leaving no room for doubt.
Symbolic	Implicitly referring to another thing.
Specific	Something peculiarly adapted.
Generic	Related to a characteristic of a whole group.
Intelligence	The ability to learn and apply knowledge.
Artificial	Made by humans.
Stuff	Miscellaneous objects with possessive personal effects.

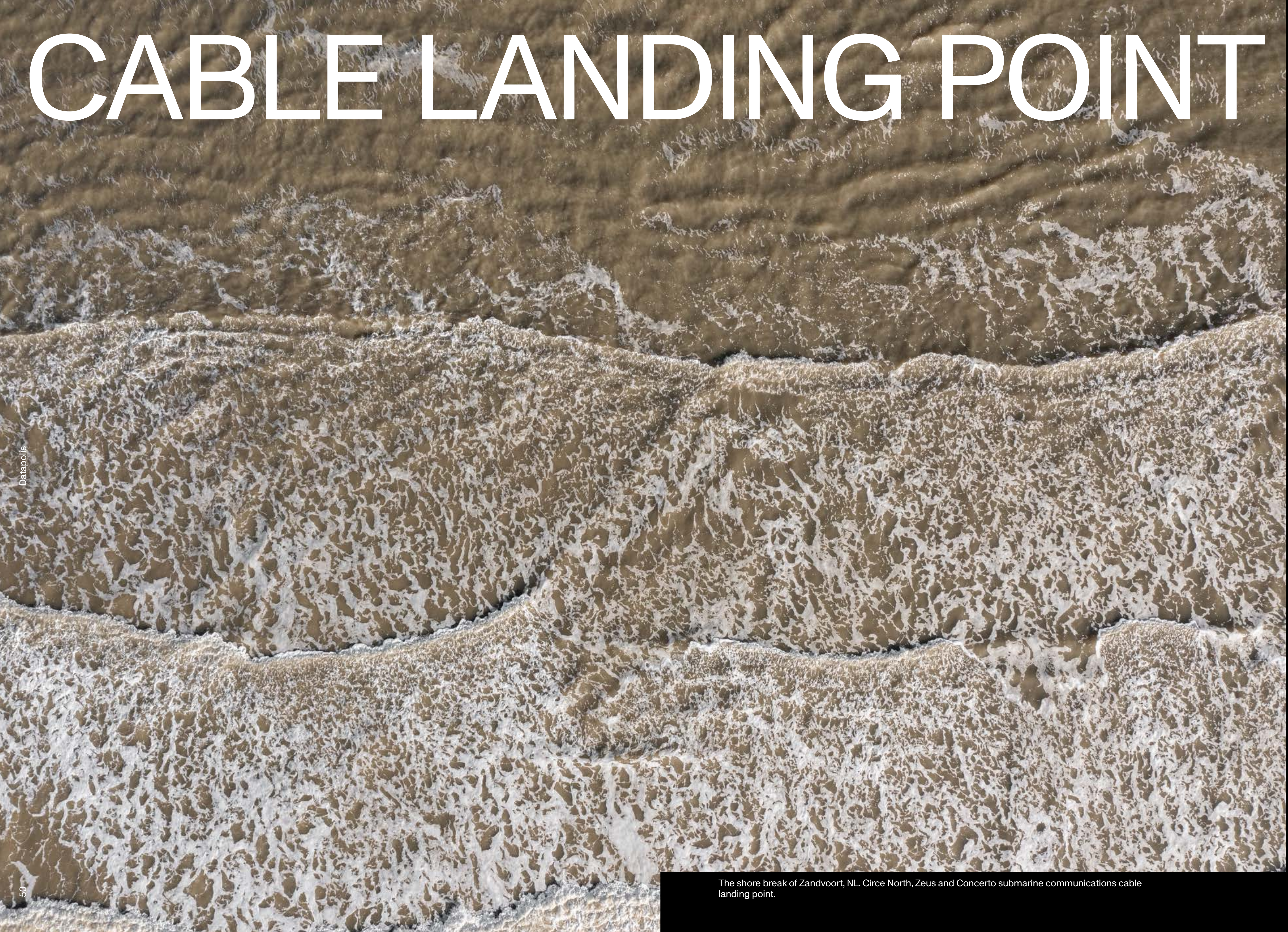
ATLAS OF D

ATLAS OF DATA LANDSCAPES
Paul Swagerman

1A	CABLE LANDING POINT	53°27’45.2”N	6°50’03.5”E
1B		52°27’52.5”N	4°34’34.3”E
1C		52°23’37.1”N	4°32’22.0”E
2	RWG TERMINAL	51°57’10.0”N	3°59’20.9”E
3	ESTEC	52°13’13.0”N	4°25’16.0”E
4	DATABUNKER	51°30’07.9”N	3°54’25.9”E
5	FLOATING FARM	51°54’46.4”N	4°24’50.5”E
6	N+P RECYCLING	51°53’00.3”N	4°25’48.4”E
7	BOL.COM	51°42’12.7”N	5°04’04.2”E
8	BACKUPNED	51°59’18.2”N	5°50’15.6”E
9	WHITE SPOTS	52°09’11.6”N	5°17’41.6”E

WIRELESS NETWORK DENSITY, MAP OF THE NETHERLANDS
Date Range: 2001–2023
Source: wigle.net
Drawing by Léa Alapini

CABLE LANDING POINT



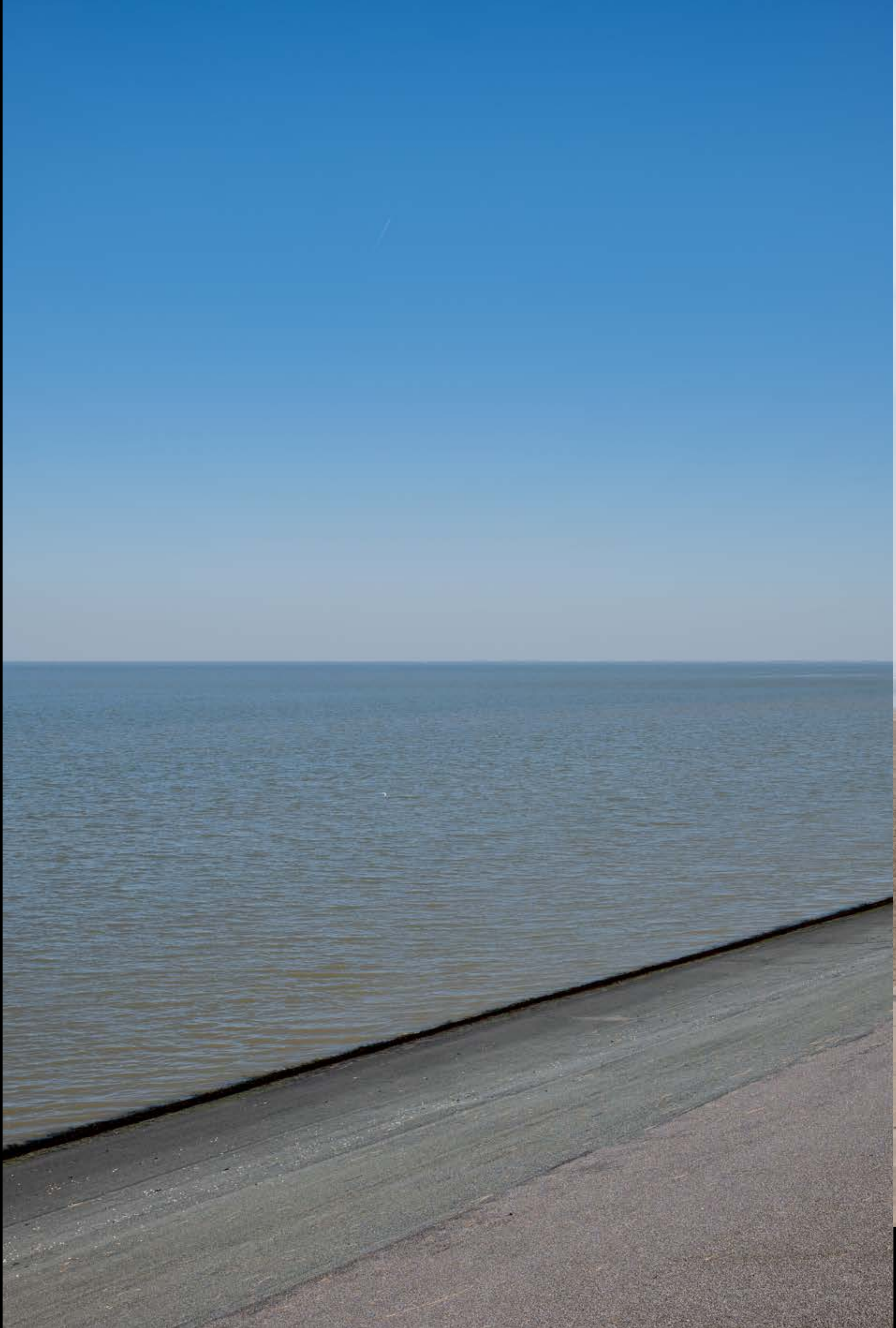
The shore break of Zandvoort, NL. Circe North, Zeus and Concerto submarine communications cable landing point.

CABLE LANDING POINT

The online map gives a hint of where the six transatlantic submarine communication cables come ashore, but the start and endpoints are hidden. I try to figure out by scanning the built environment, or some discontinuities in the landscape, if there is some way to find any sign or trace of their presence. The only reference is a small sign in Noordwijk mentioning Free WiFi, and some oversized electricity follies or small poles that are associated with it.

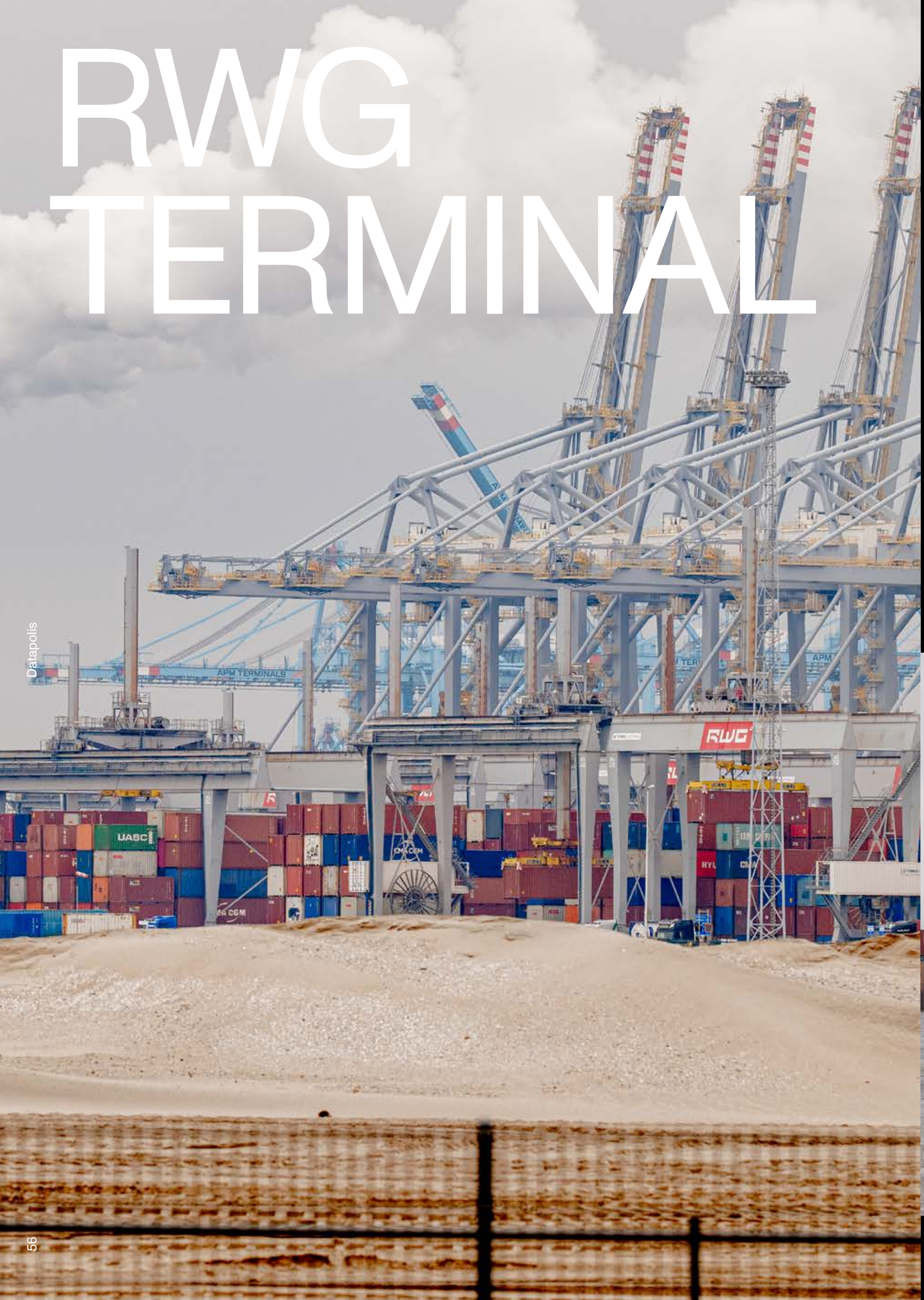
On an icy cold sunny autumn day, people stroll along the coast, joggers and mountain bikers pass by on a beach covered with deeply carved out tractor tracks. The paths make me wonder if they secretly indicate the most critical communication infrastructure. A mega-scale network, impossible to see.

↑ Circe North, 1999, length: 203 km. The landing point at the other end of the cable: Lowestoft, UK. Zeus, 2022, length: n.a., other landing point: Lowestoft, UK.



← Eemshaven, NL. COBRAcable, 2019. Length: 304 km. The landing point at the other end of the cable: Endrup, DK ↑ IJmuiden, NL. Scylla cable, 2021, length: 204 km, the landing point at the other end of the cable: Lowestoft, UK.

RWG TERMINAL

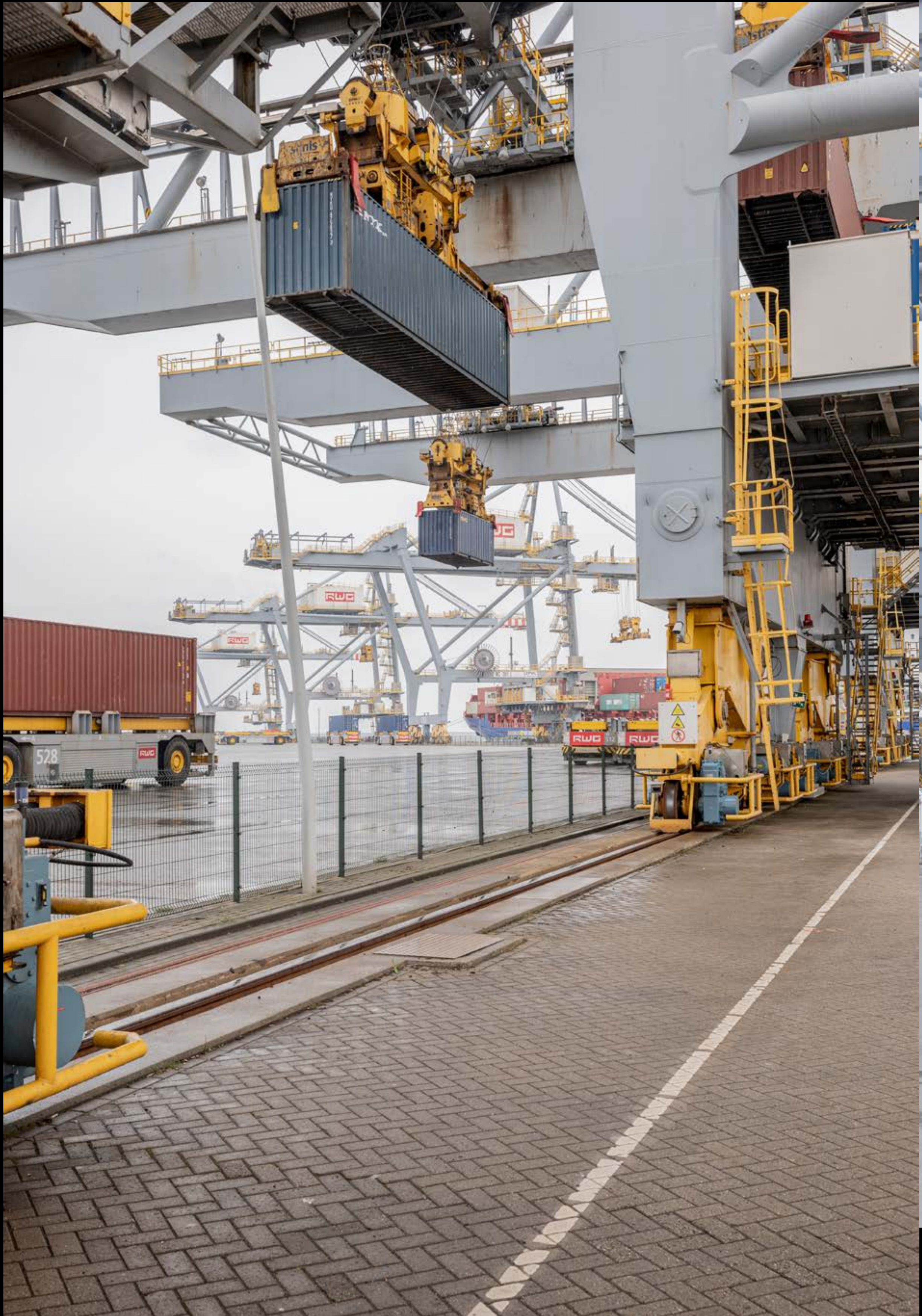


RWG TERMINAL

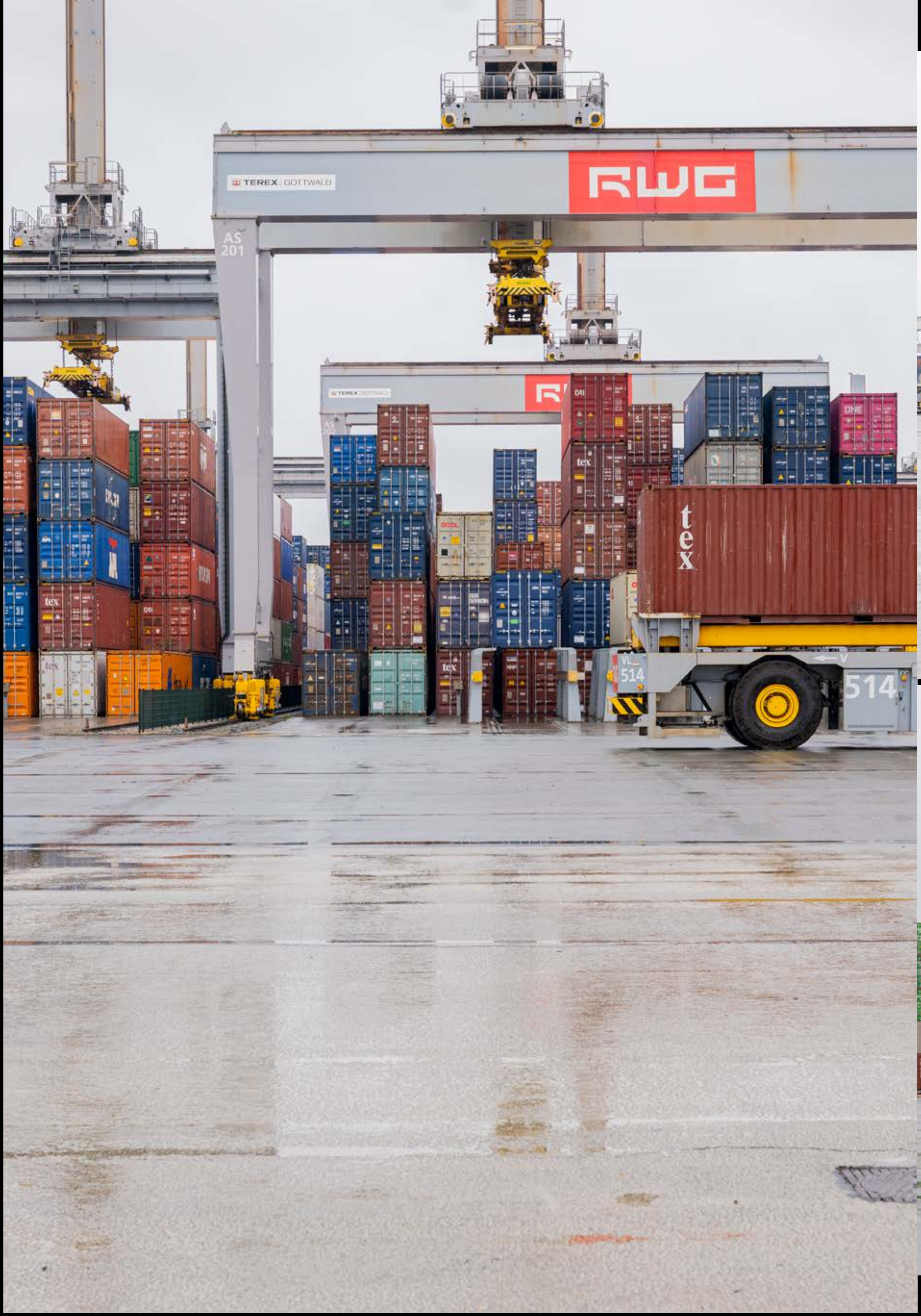
On the most newly created land around Rotterdam in the Netherlands you can see the huge amount of development and expansion potential of the port. Ten years earlier I would have stood on the bottom of the sea. Now, smooth asphalt and slickly designed bridges provide the essential logistics infrastructure for a new port area. The harbour basin closest to the access from the North Sea draws attention with its gigantic blue cranes and white frames, and is constantly in motion. A complex network of train tracks and small single-lane highways on different levels all lead to the RWG container terminal, the largest fully automated container transhipment in the world. Trucks without cargo move in, are identified by a scanner, and just-in-time pick up their brightly coloured container, the exact one out of 50,000. This is the only place where there's a human presence.

Beyond the trucks, a truly fascinating choreography of autonomous vehicles (ATV's) takes place, in a strictly prohibited area enclosed by fences. In the pouring rain they quietly follow an invisible grid in an almost confident way, picking up or delivering containers from the deep-sea vessels. They intelligently sort out where to store each one for short or long stay. When out of power, they pause for a minute in their garages, their batteries are swapped behind a closed roller door and then they continue their duty, 24:7, year round. In theory, people never have to intervene.

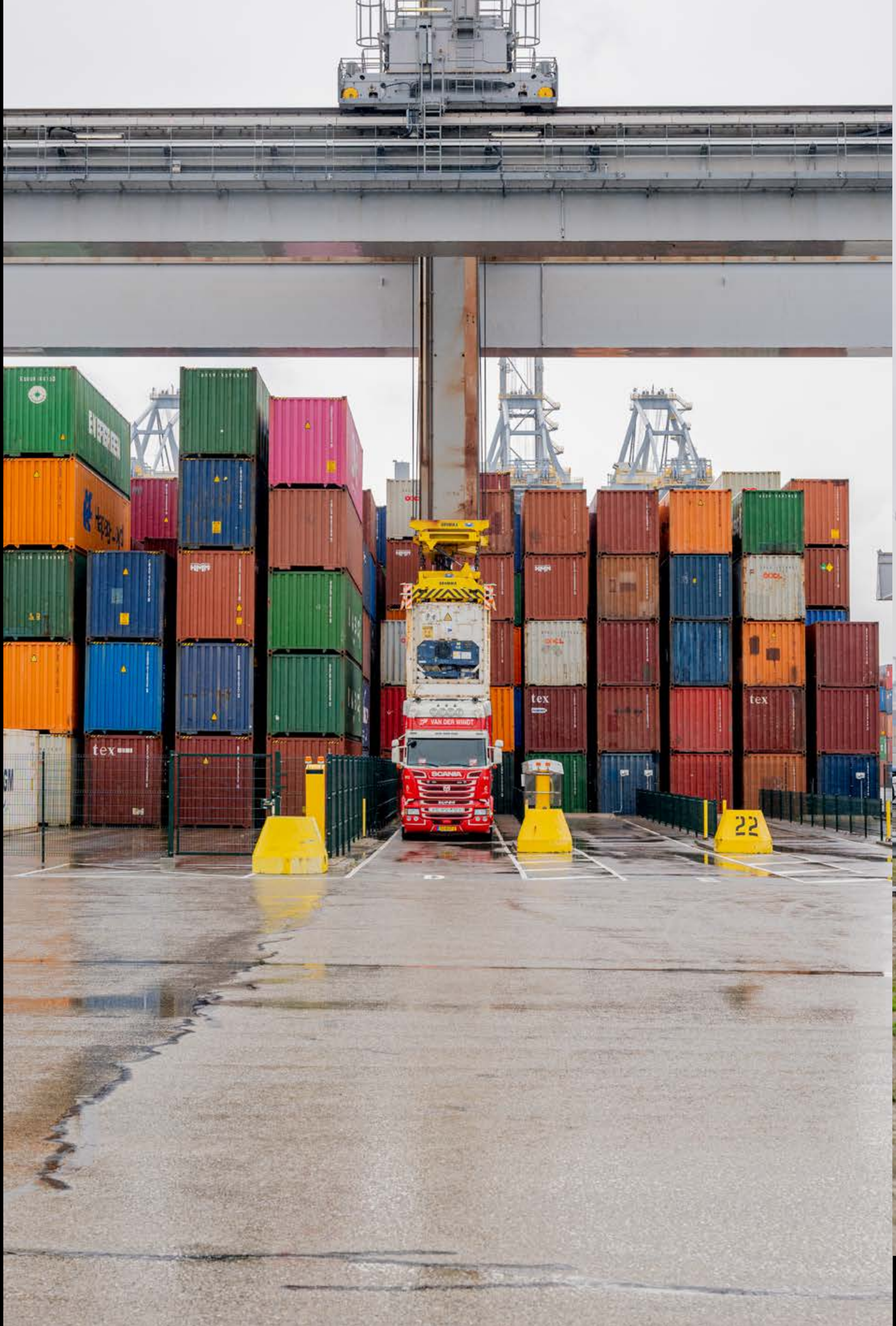
↑ AGV's (automatic guided vehicles) drive into the battery exchange station for a battery swap. In ten minutes, they are ready again for six to nine hours of driving.

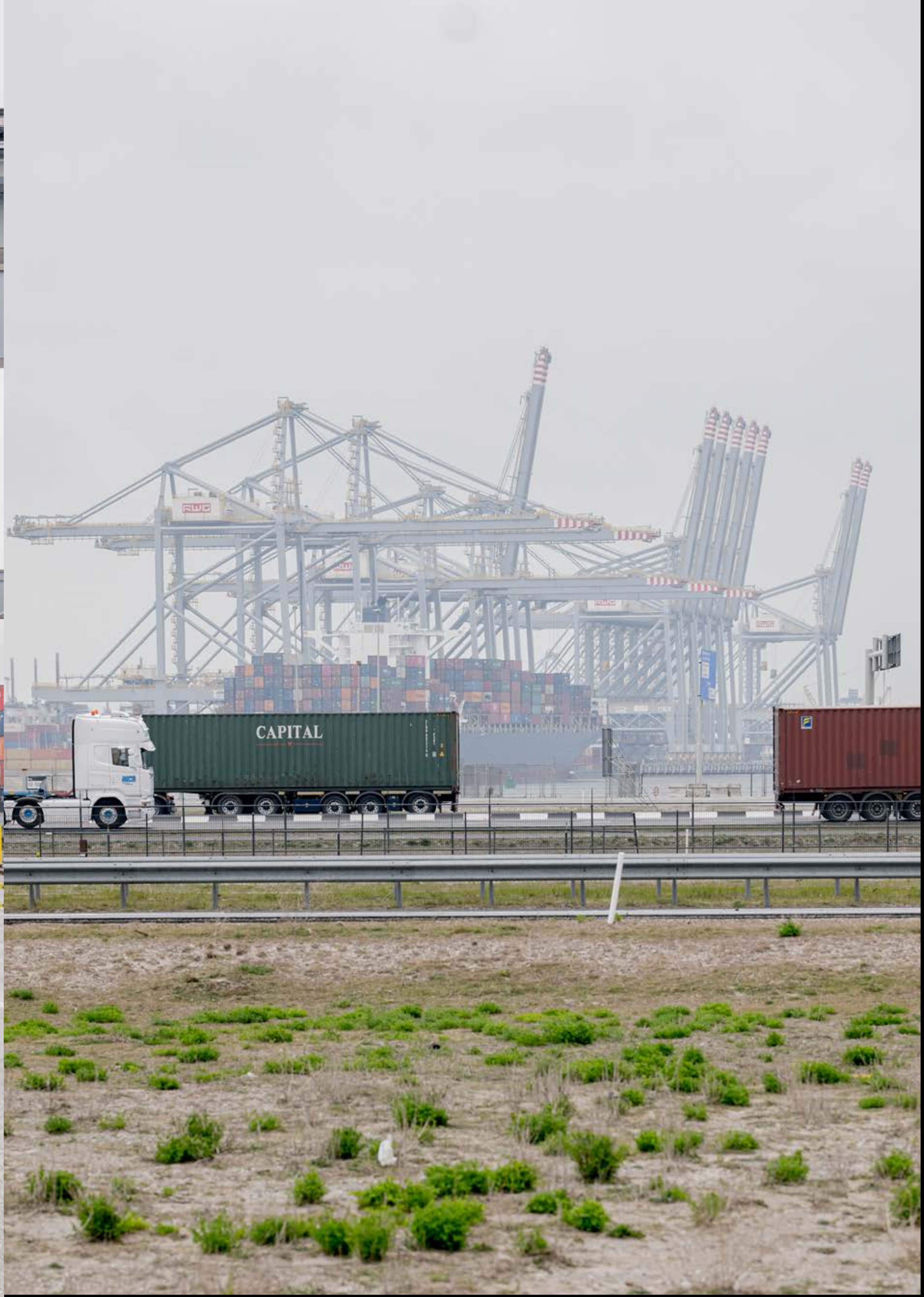


↑ Thirteen deep-sea cranes, three barge/feeder cranes and two rail cranes are used to move containers from barges, feeders and deep-sea vessels onto the container storage area.



↑ Fifty Automatic stacking cranes move 2.35 million TEU (Twenty Foot Equivalent Unit, the dimension of a container) annually, which is approximately 90.5 million m³.





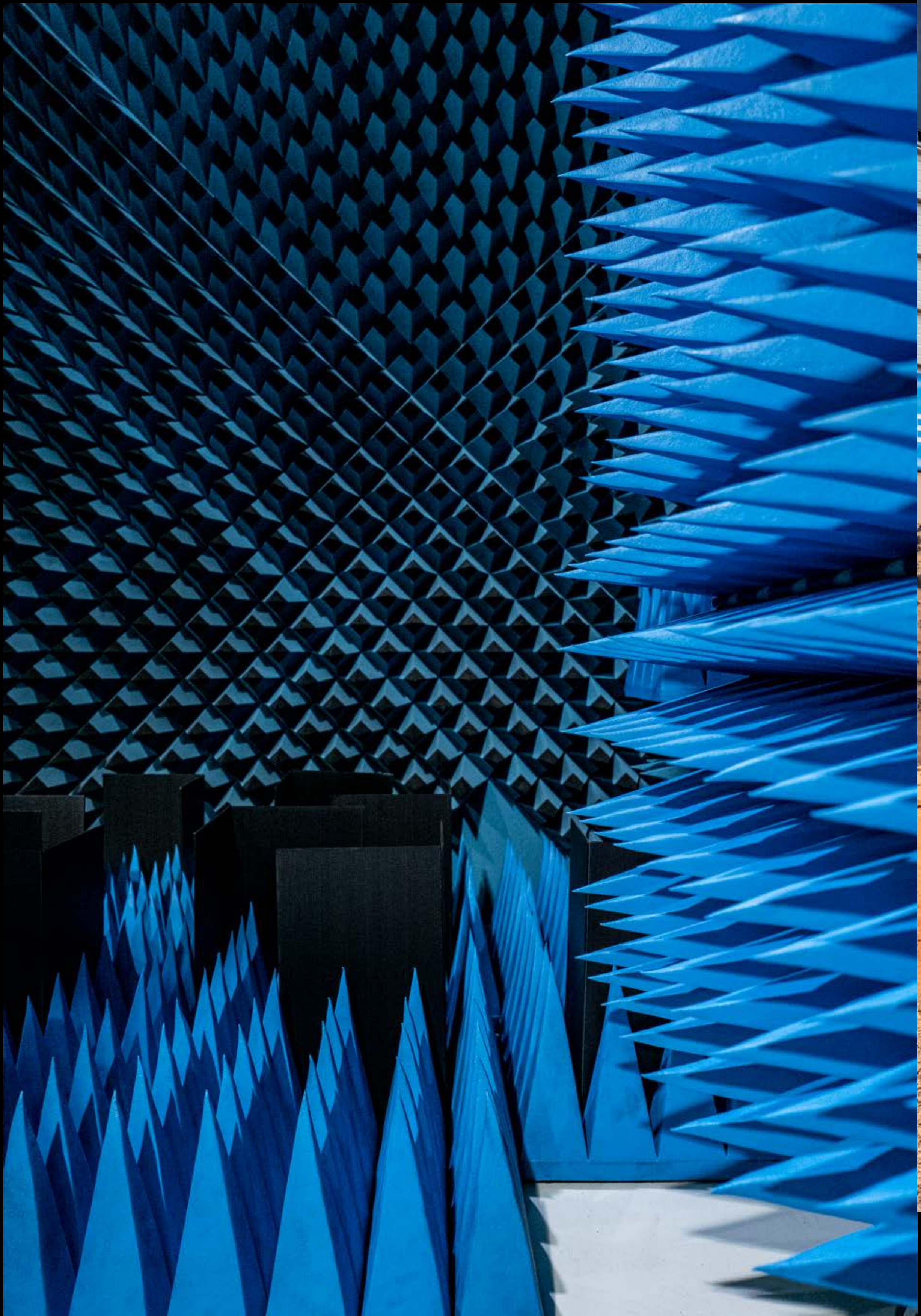
↑ Around 80% of the containers, stored on RWG, are distributed by truck and 20% by train.

ESTEC

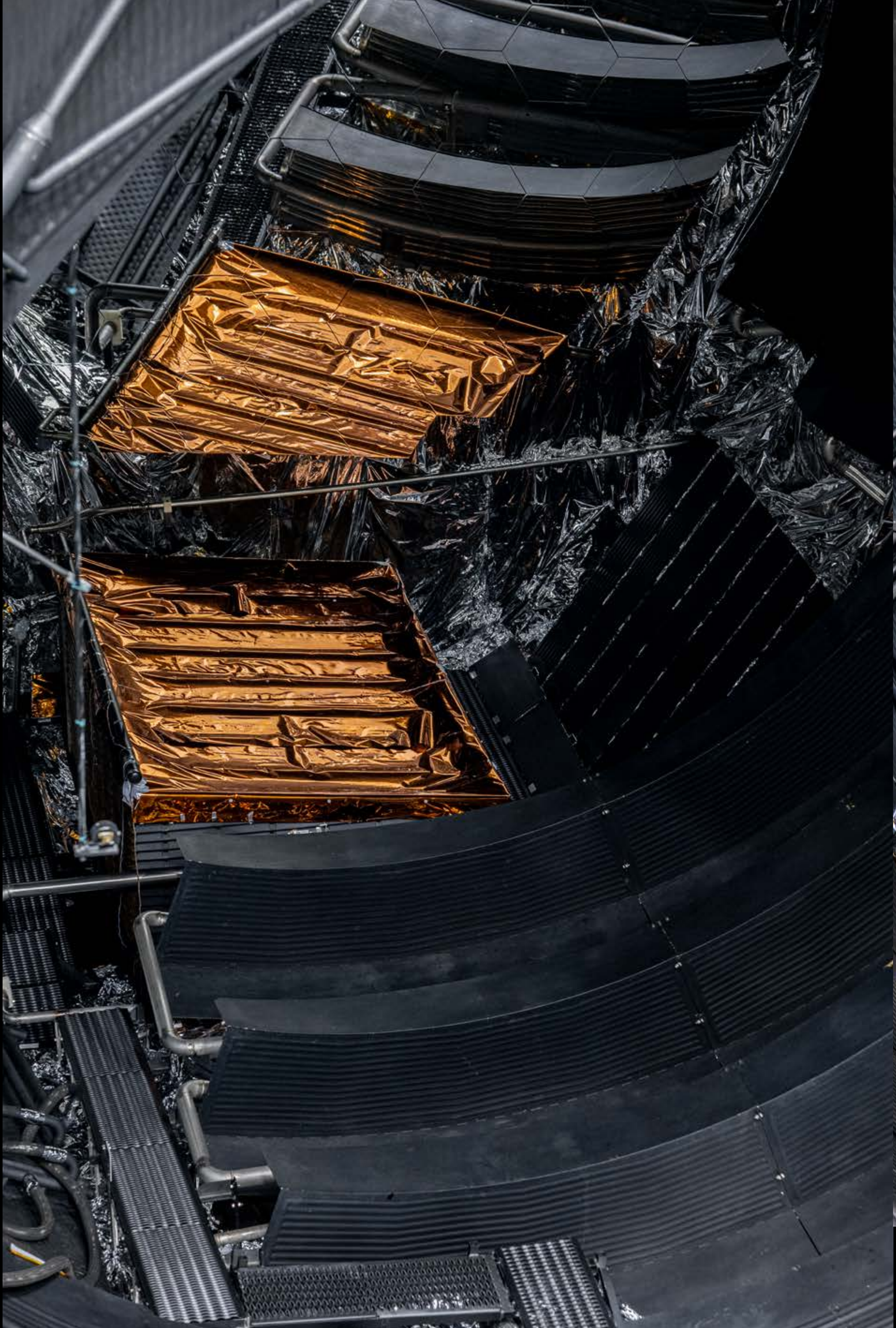
ESTEC

In stark contrast to the endless surrounding residential areas, the ESTEC (European Space Research and Technology Centre) is wedged between the city of Noordwijk and the dunes. From the entrance gate and reception desk, it's already clear that this is a distinct area, marked by an outdoor exhibition of dysfunctional satellites and other unnameable objects. This is where, prior to launch, instruments get tested in the conditions of space, improper and unnatural to Earth. The guide speaks quickly with her French accent, and continuously calls her colleagues about the possible and impossible spots to visit and capture. Every door is opened with a pass, and behind each door is another door, sometimes marked with a red lamp: test active. We walk through a maze of boxes, interconnected by winding walkways and sizable parking lots. There's a massive deep-black tube where the sun's reflection is simulated, abstract rooms that isolate all noise distortion, an immense shaking platform, and a large microwave-sized apparatus that simulates years of exposure to the sun. At the end is a decor of a Martian landscape for robots, which are sometimes let out in the nearby dunes.

← Nitrogen tanks cool down the space environment simulation testing facilities below -173.15°C, corresponding to the shade's temperature in space. ↑ Flight model of IXV (Intermediate eXperimental Vehicle), for testing critical systems and technologies for return missions from low Earth orbit.



← EMC anechoic chamber. The chamber's design blocks out outside sound and absorbs acoustic echoes to simulate a space environment. ↑ A half-scale ExoMars rover is tested on terrain representing Mars's surface, which is made of sand and volcanic rocks, taken from different sites in Europe.

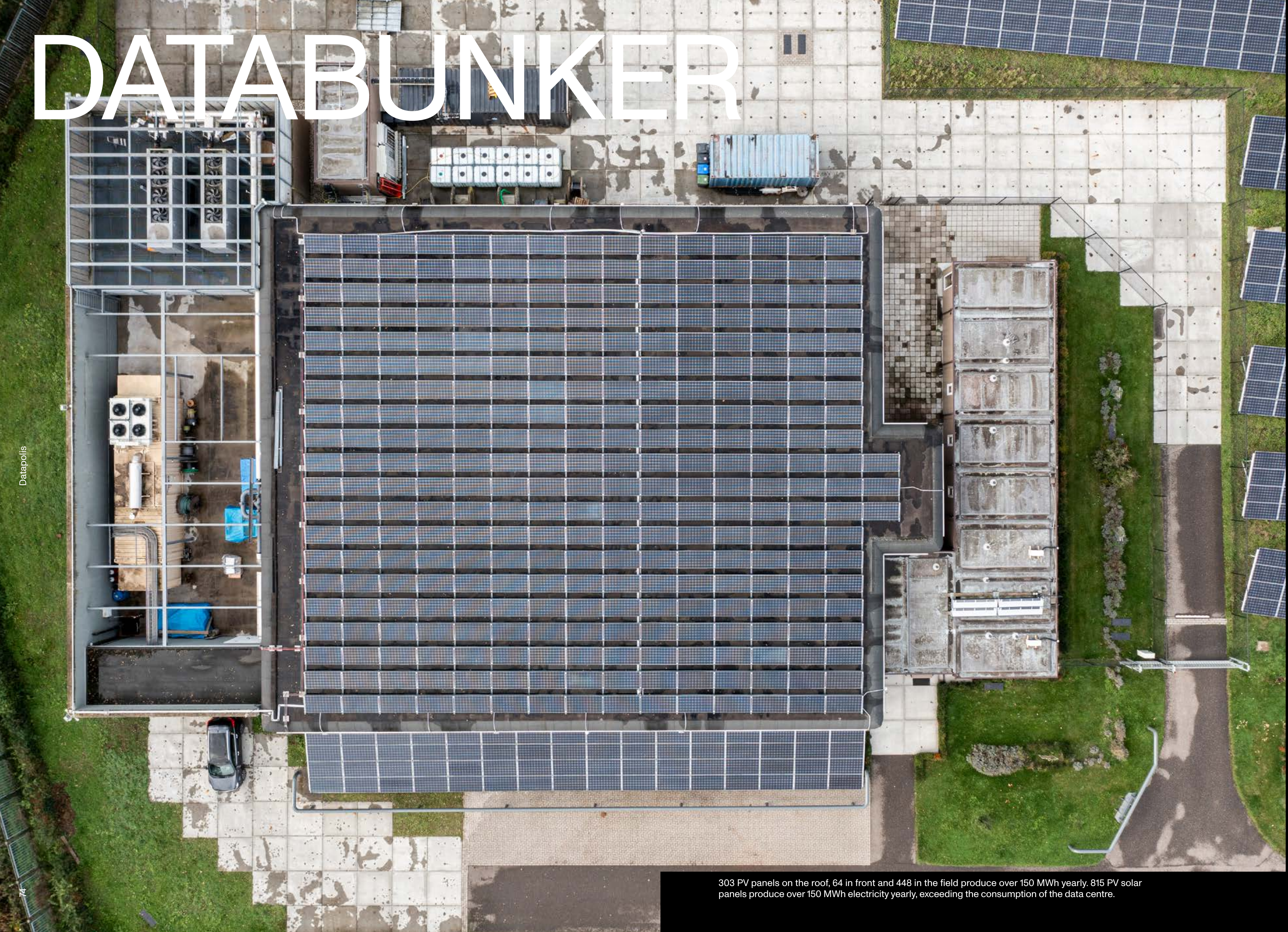


← The solar beam entrance exposes the satellite to horizontal solar beam of 6-m diameter with excellent uniformity and very long- and short-term stabilities. ↑ Inside Europe's largest thermal vacuum chamber, wherein a mock-up of ESA's exoplanet detecting spacecraft named PLATO is being tested.

← STAR II testing facility where temperature-controlled samples are exposed to radiation sources after which the thermos-optical properties are measured in-situ without breaking the vacuum. ↑ ESA's Large Space Simulator, the largest thermal vacuum chamber in Europe.

← HYDRA, the largest satellite shaker in Europe is a multi-axis vibration test facility for satellites. It can generate vibrations equivalent to an earthquake of 7.5 on the Richter scale. ↑ HYDRA, the 5.5 m octagon-shaped test table of 21 tonnes is excited by eight powerful hydraulic actuators (four vertical and four horizontal).

DATABUNKER



303 PV panels on the roof, 64 in front and 448 in the field produce over 150 MWh yearly. 815 PV solar panels produce over 150 MWh electricity yearly, exceeding the consumption of the data centre.

DATABUNKER

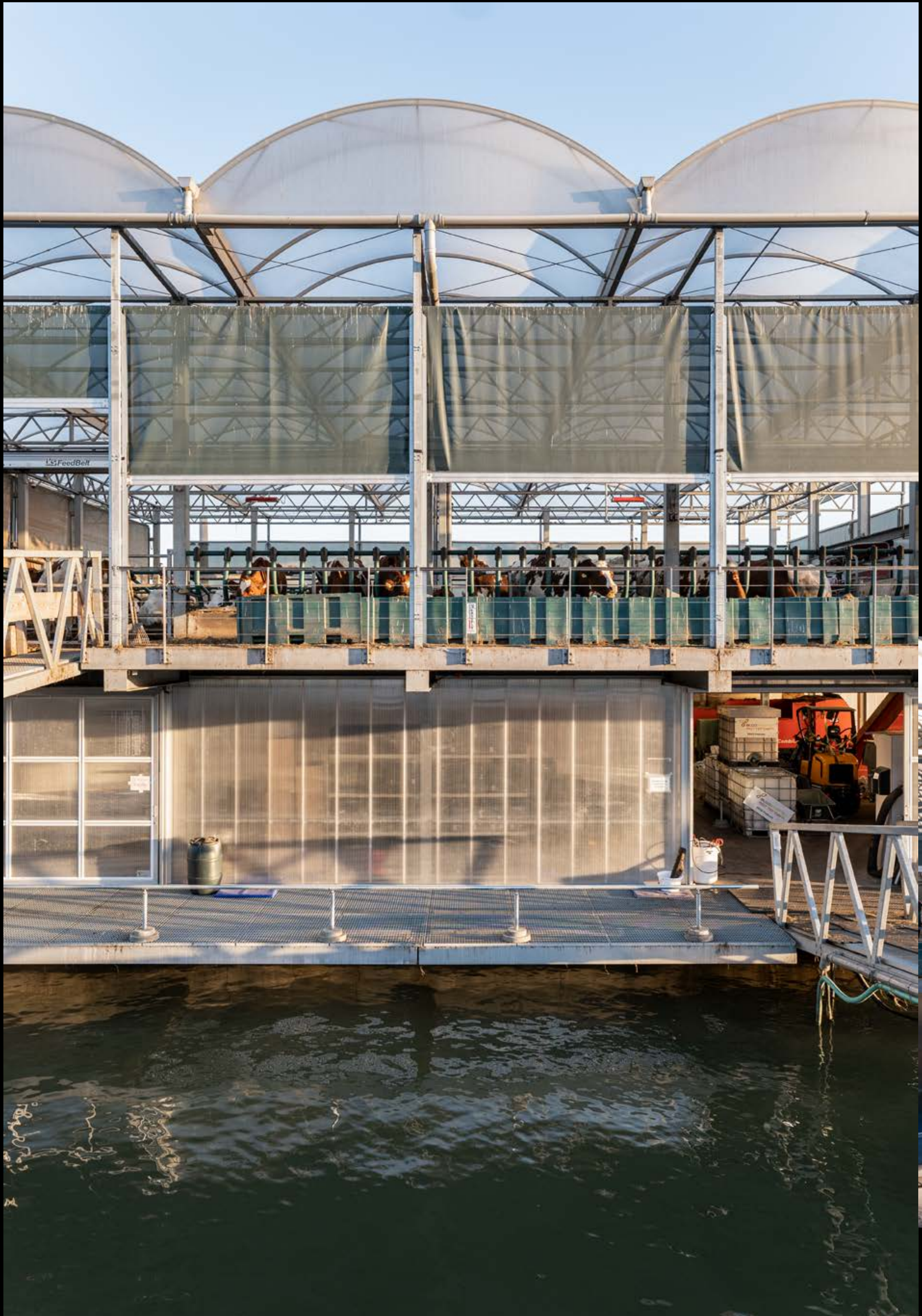
The DATABUNKER is situated adjacent to a completely average Dutch 1970s neighbourhood and is reachable via a narrow driveway, secured by three automatic gates. Surrounded by agricultural land and a sports field, a pale, monolith brown structure is hidden behind faux-wooden barracks and protected by thick anti-ram raid tubes. Behind one of the barracks the original 1955 stamp is embossed in concrete and hidden from sight as if the structure wants to hide its original purpose. The whole structure is centred in a field of solar panels and camouflaged by tall poplar trees. Traces of its original purpose, an atomic-war bunker that served as a governmental communication headquarters, are clearly visible on the ceiling, walls and floors. The massive concrete box seems to have undergone a surgical operation with tubes for cooling water, data- and power cables passing through the walls, roof and between the spaces, PV-panel converters, security cameras, H-steel frames and small antennas, all clicked onto the concrete surface like addons. Nothing indicates that this is a place where data is stored for a specific type of client that requires the highest level of data security, and I wonder if data is more protected when encapsuled in a 5-m-thick layer of concrete. It is fascinating to witness the layers of time and the fleeting technological systems that have, for now, nestled in a former top-secret call centre.

← Entrance with solar panel array and ram raid barriers. ↑ A ‘hot corridor’ in one of the co-location rooms, containing server racks under a black steel ceiling.

↖ Transformers transform high voltage 10kV to 400V. ← Ducts and air conditioners on the exterior wall, for cooling the servers and to air-condition the former command and control room. ↑ The painted red and blue tubes connect to the super chillers and are part of the cooling system of the Databunker.

FLOATING FARM

In the Floating Farm, in the old harbour of Rotterdam, the cows are housed on the semi-transparent upper level and the floating solar panels supply electricity.



FLOATING FARM

In a harbour basin between the cities of Rotterdam and Schiedam the area is partly active with logistics, and partly the remnants of a former industry are visible. Massive cranes form a skyline on the horizon. Wooden fences surround a small lot of muddy grassland, where cows graze and slowly move towards a white iron bridge, one after the other on the same path or pace. At the same time, a small van with a rolling cart comes in. When bridging the water, the cows go to the top, and the cart goes down.

The functions of this floating square volume are clearly distinguishable from the outside, the cows are on the upper level where the wind flows through the open structure of steel with a roof of plastic arches. Next to the volume floats a solar panel field in the shape of a milk bottle. Suddenly a curtain of cattle feed descends, while simultaneously a small red turtle-shaped Lely Sphere Manure robot slowly sweeps and sucks the floor, and a large brush cleans a cow. In a strange way, the slow swell gives a peaceful feeling of a classic farm homestead and I almost forget that I'm in the middle of a dense urban area.

↑ The produced milk, yoghurt, butter and cheese at the farm are being transported to a van that distributes them in and around the city of Rotterdam, to restaurants and directly to consumers.

← Through the funnel, the cow's manure and urine fall from the upper-level stable into the lower-level big bags and the containers. ↑ Cows are fed three times a day through the feed-belt with residual products from the city like bread, beer broth and vegetables.

N+P RECYCLING

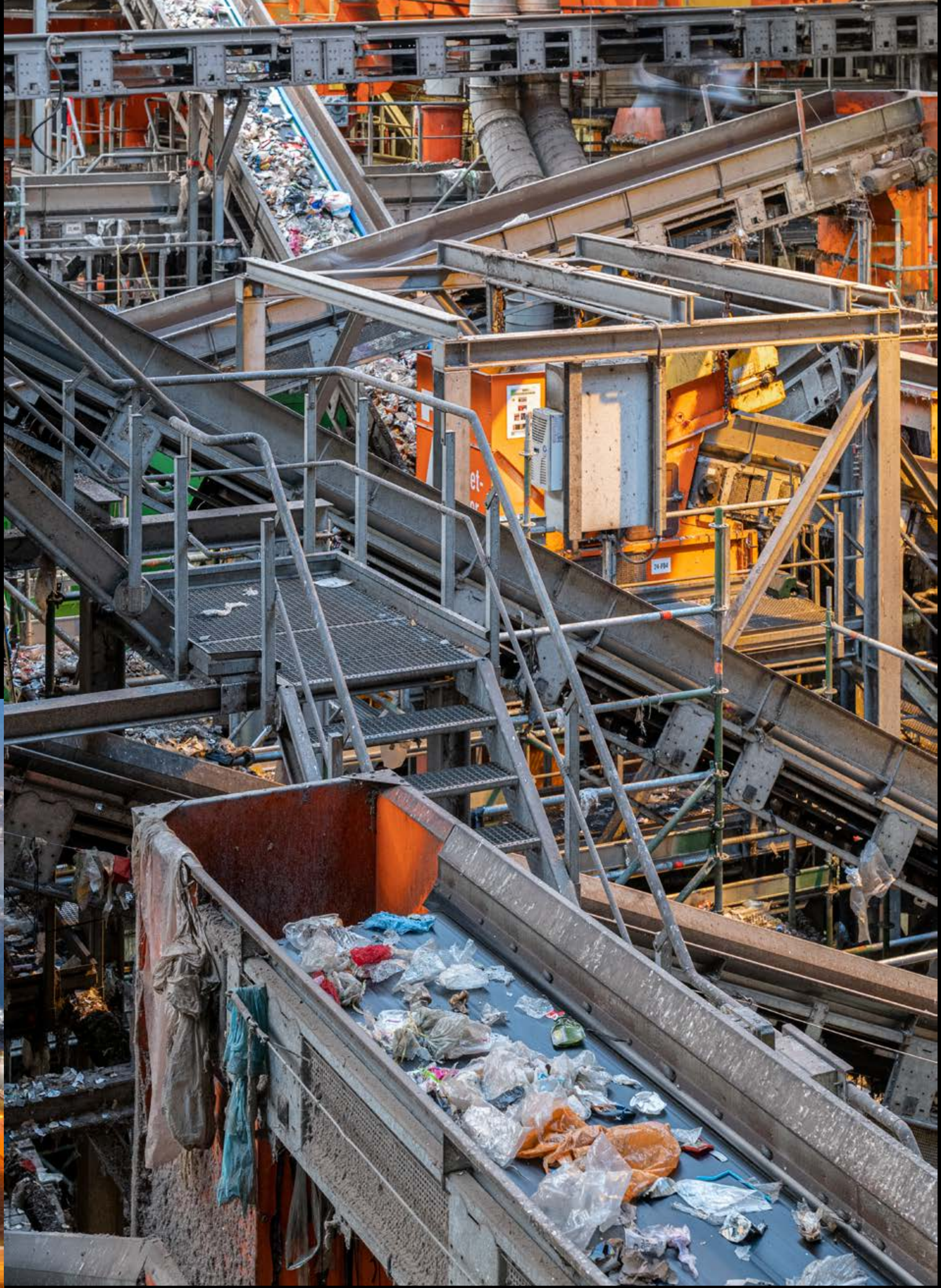
Screening drum, wind-shifter and magnetic separator are interconnected by conveyor belts.

N+P RECYCLING

Entering the waste separation machine is like entering a wondrous game environment. The massive hall is spanned by a beltline; like a 'bridge' between the torn bags that enter through cut-out holes in the steel plates, it divides the temple of recycling into different sections. In the space interconnected by grids, stairways and steel H-profiles, one is allowed to follow the green marked railings and catch a glimpse of a scene that resembles one of Piranesi's prison drawings, in reality. Overwhelmed by the quantity and speed of the 12-step plastic recycling process, I almost wonder why this is not accessible as a theme park attraction.

All of the German Orange machines are connected to each other by homogenous tubes. Generating a constant vibration and exceptional soundscape through the structure, they scan, suck, blow or magnetically attract any object that is not made of plastic. While his private kitchen is orange, the director thinks orange is an ugly colour; he would have ordered all of the machines in blue if there had been a choice.

'Why are you as architects visiting this place? When I think about architecture, I think about buildings,' the director of the automated plastic separation plant asked. For him it is such a self-evident fact that the 400 × 30 × 30-m volume situated in the southern part of the port of Rotterdam is not architecture, but merely a system—an infrastructural machine, something that could not have any other appearance than what it is constructed of. It is so instrumental and logical that it could not be architecture.



← The N+P recycling centre in Waalhaven, Rotterdam receives 500 tons of waste daily. ↑ The main hall. The optical separator separates beverage cartons, the magnetic separator and aluminium separator remove metals from unsifted waste.

← The wind-shifter separates lightweight foil from plastic. ↑↑ Incoming waste. Sifting starts in the supply hall where waste from the acceptance area is spread with cranes and bulldozers. ↑ The semi-finished product. Approximately 1,000 bales are stored daily in the storage area before turning into raw materials or alternative fuels.

BOL.COM

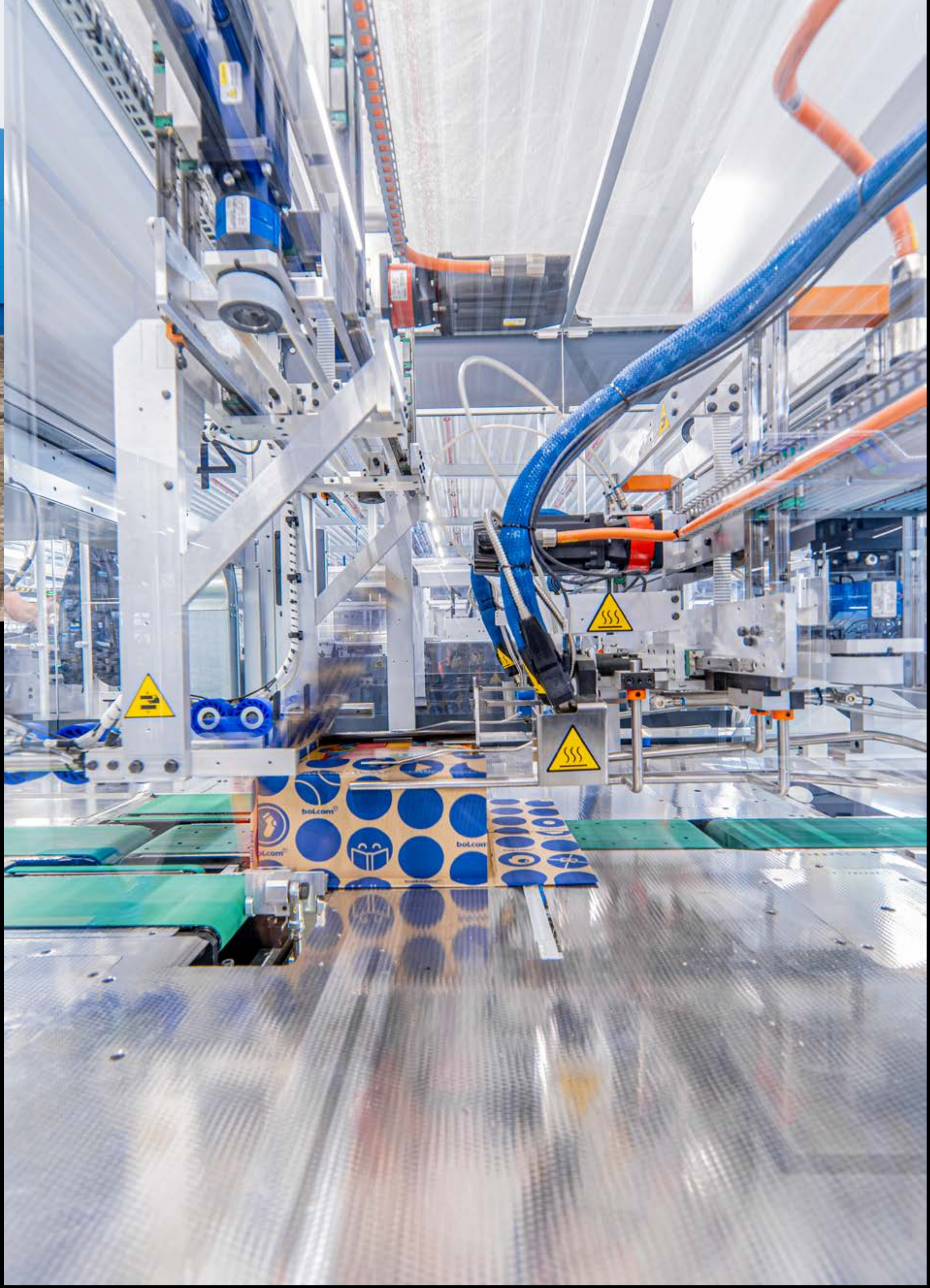
The distribution centre measures a ground area of 100,000 m² and a floor area over 240,000 m² in three floors.

BOL.COM

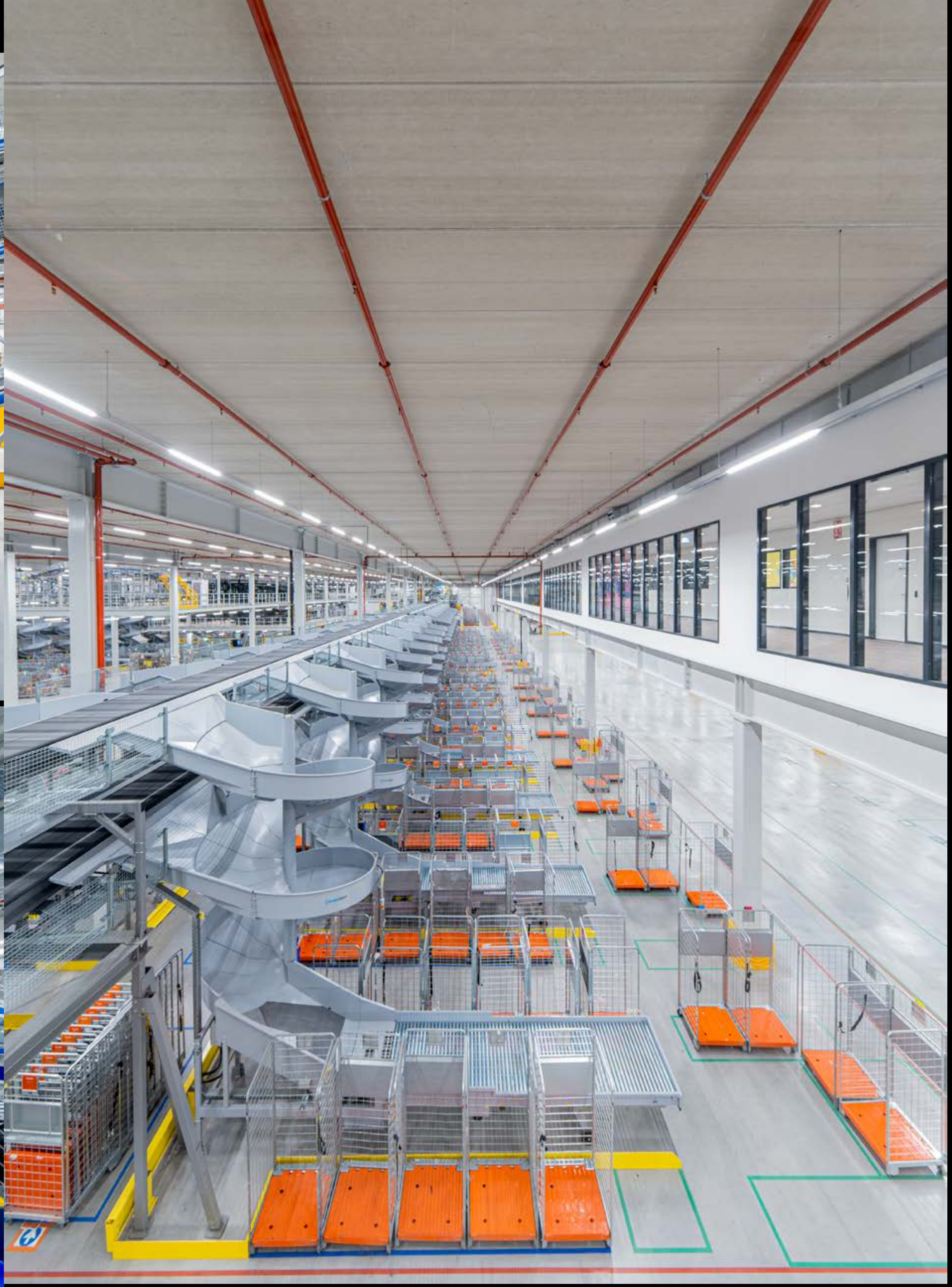
A very wide duotone-coloured box with a blue and grey stripe across its entire width looms up on the outskirts of Waalwijk, one of the many industrial zones in the Netherlands. It is located, as if with a wink, at the end of the street called Pakketweg—which means 'package road' in Dutch. A large open, former agricultural field on the right side of the mega-box is bordered by a dike, or something resembling a mountain of waste. A battery of windmills and a field of PV panels cover the hill.

Every now and then a truck drives back and forth, but nothing indicates that the most successful logistics operation in the Netherlands is taking place here. The peak of inbound and outbound traffic is at night, when the flow is least hindered by traffic jams.

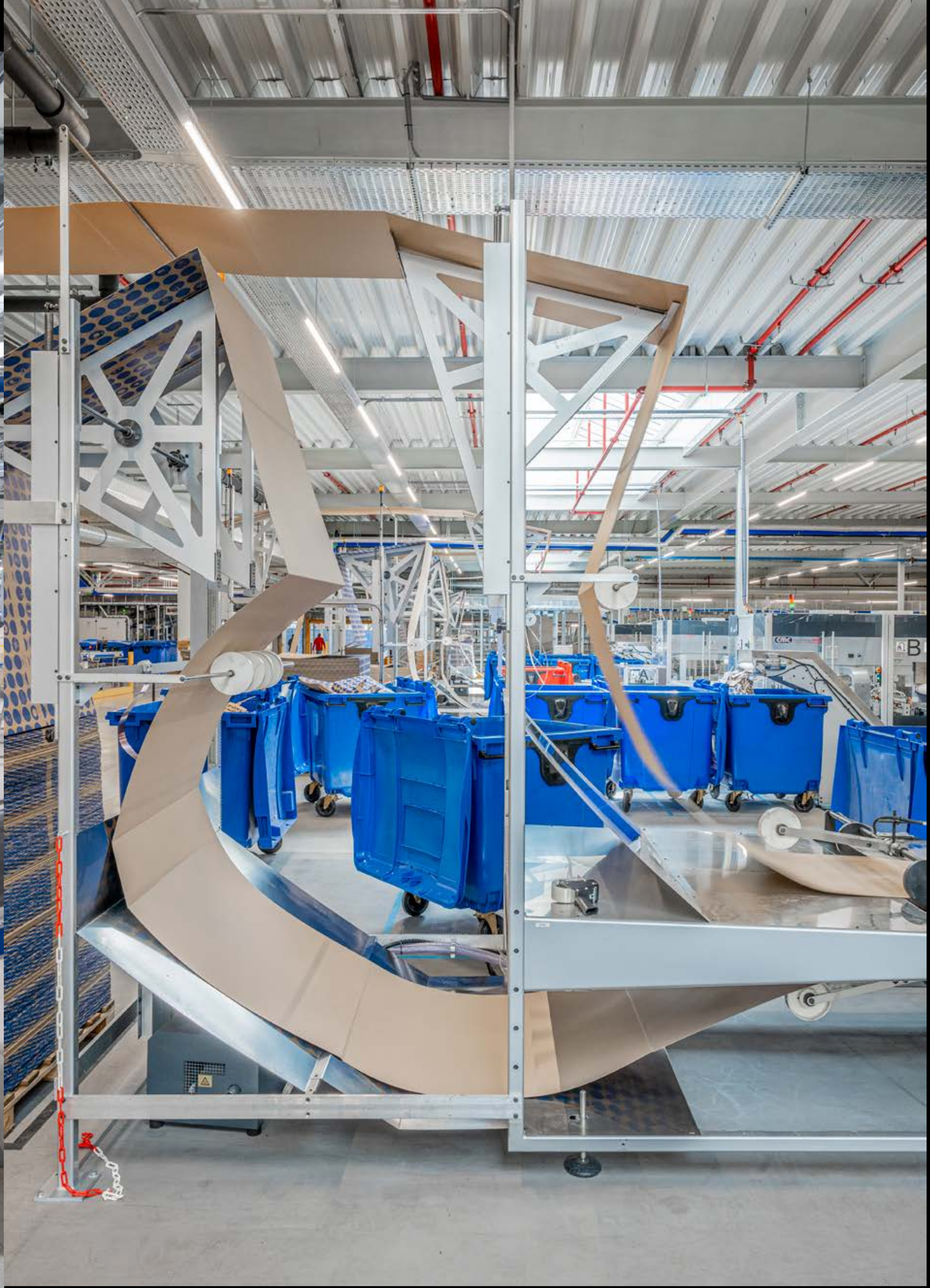
It is difficult to see the size of the 20-hectare complex in its entirety at a glance, with its endless number of loading and unloading areas for trucks, it is almost a landscape in the landscape. A box full of boxes wherein only one principle is facilitated: the flow of goods to people. It is not the only term that refers to the feeling of an airport, the whole complex is reminiscent of an airport luggage pickup hall with its endless conveyor belts that swing through the entire complex like a roller coaster. The entrance where I got in contains the most strict security checks I have ever experienced; the ultimate check is that the IMEI code of my phone is registered so that I can be tracked in any location within the complex. The two colours of the exterior are complemented inside by a bright coding system of red, yellow and blue. It suddenly becomes clear that this is the physical reality behind the click on the 'buy now' button. The initiation of a linear process of scanning, sorting, folding, wrapping, packaging, labelling, shipping and the mechanical logic of bodies who move between the machines and rolling belts.



↑ Twenty-five Packing machines pack the single-item orders as customized as possible. The dimension of each item is scanned, then the cardboard is cut and folded into the exact size of the object.



↖ Totes containing small to medium items are mechanically stored and retrieved via conveyor belts when an item needs to be picked for an order. ← Belt with integrated scanner to manually sort a customer's order with products stored in the warehouse. ↑ The outgoing package section contains 86 chutes and two conveyor belts atop each other to increase sorting capacity on a smaller footprint.



← The new generation of vertically oriented packaging system. ↑ Double carton infeed for the carton wrap package cutting machine. Each feed has a different width to reduce the carton waste.

BACKUPNED

The central scanning point is located between two tape rooms, where the full registration of the in- and outgoing tapes takes place.

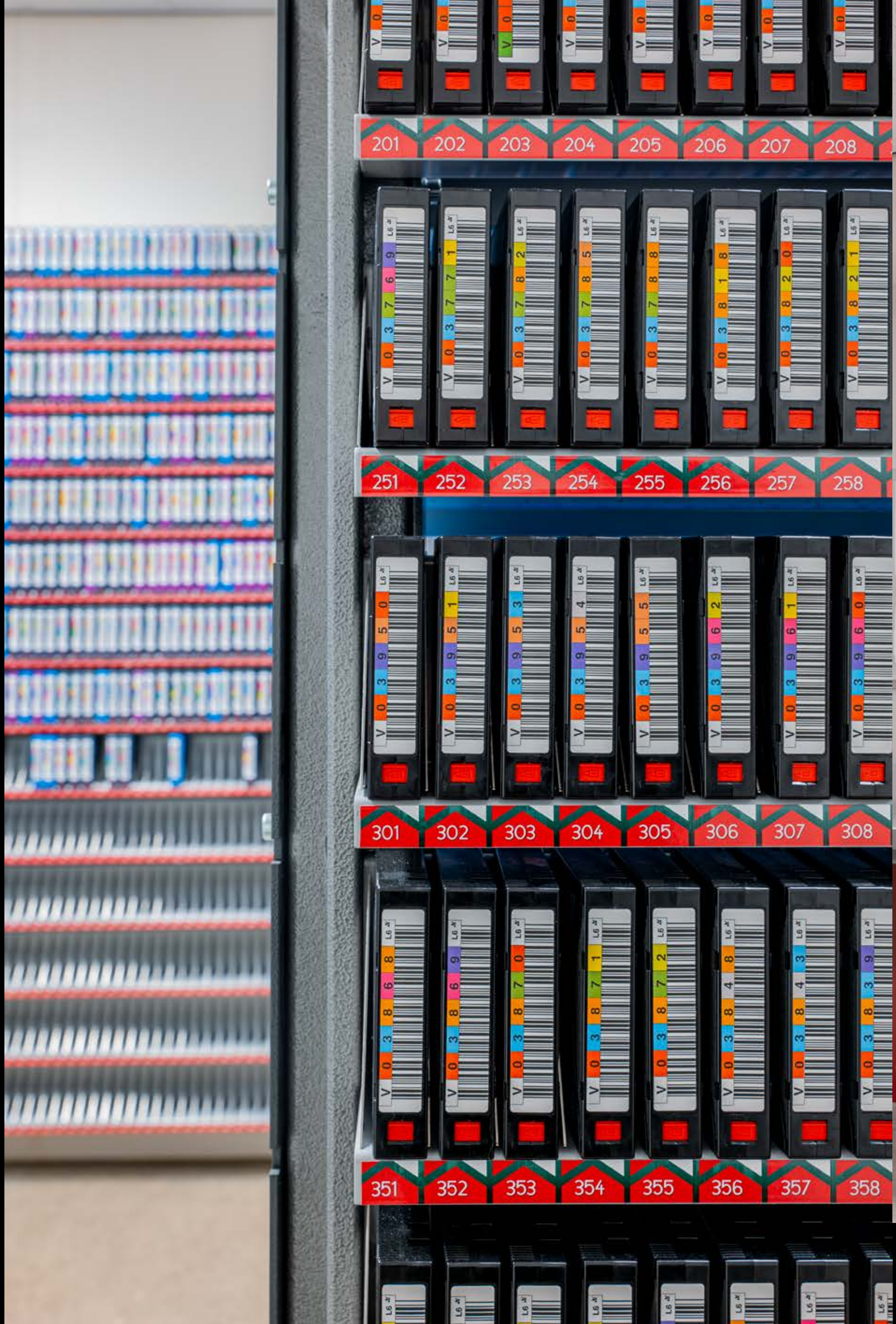
BACKUPNED

Tall grass waves in front of a generic white bungalow. The association of a private house is confusing; the oversized entry is just to the left of it. The heated driveway with its steep angle of inclination is used daily by small vans, following a strict schedule. They pick up and deliver hundreds of similar, sealed suitcases of which is unclear what the exact contents are.

Nothing indicates that possibly the most classified information is stored here. Because of the Covid situation, Backupned got rid of its pre-war office villa that merely served representation purposes, and operates solely from its cold-war atomic bunker situated in a pleasantly green, hilly and quiet neighbourhood in the Arnhem region. I enter a long hallway with a thick steel door, a blue LED light and screen with projections of security cameras resemble a constructed film scene of a science fiction movie. ‘Everything should be organized; so structured, clean, aligned in a consistent way, otherwise clients will not gain enough trust,’ the director explains his reasoning behind the organization of this peculiar backup facility. Rows of tapes, colour-coded by client and labelled with codes, make it feel like an anachronistic VHS video-rental store. ‘But tape is far from an outdated data storage medium. Innovation is still going strong and demand is becoming higher and higher.’ This is the opposite of on-demand; here, data is stored that might one day be summoned, and maybe with extreme urgency—when needed, there’s a chopper available to deliver throughout Europe within a timeframe of hours.

← The main presentation room. Tapes are stored in TAP-racks, 50 racks can store 600 tapes.
↑ The backup facility is a bunker, disguised under a bungalow: a legacy of the Cold War.

One of the main halls containing approximately 35.000 tapes. Empty shelves are reserved for customers to anticipate on their data growth.



← A LTO tape is a magnetic tape data storage technology with the capacity of 45 TB. Originally it was developed in the late 1990s as an open standard alternative to the proprietary magnetic tape data storage. ↑ Outgoing tape room.

WHITE SPOTS

Soesterduinen, NL, Nearest phone cell tower: T-Mobile, 1,957 m.

WHITE SPOTS

In one of the sparse original sand drifts of the Netherlands, I meet a small group of middle-aged women who are there for an afternoon gathering. The woeste grond (an unproductive landscape that has not been cultivated), is a vast dune landscape in almost precisely the centre of the country, burning the eyes in the sun at its highest point. The group of women, who suffer from Electromagnetic Hypersensitivity (EHS), gather physically; their meeting is arranged by email conversations over a landline instead of via Wi-Fi or cellular communication. To make sure I don't interfere with their attempt to hide from the cloud of data waves, I activate flight mode on my iPhone. Beforehand, I check for nearby radiation with the White Spots app. A virtual forest of red spikes indicates that the closest transmission towers are around 550 m away.

I'm curious about all the practicalities that one encounters in a world of invisible and intangible signals that are impossible to avoid. And before I get to observe their walk we fall into an extensive conversation. They explain how they found each other in the shared ambition of creating awareness in the outside world of their illness. Among those who should take their sensitivity into account, are architects. This is already the case in Germany, where triple-paned glass and a strong separation of Wi-Fi signals in different rooms in houses or hotels lead to their radiation-measuring instrument showing much lower results. Martine says the most basic feeling is that of not being protected, being under constant stress, and one of the women talks about how the only place she can escape to is the Egyptian desert. Suddenly I understand why they chose this location as their weekly escape from data.

← Soesterduinen, NL, Nearest phone cell tower: Vodafone Libertel, 1,257 m. ↑ Soesterduinen, NL. Nearest phone cell tower: T-Mobile, 1,085 m.

ESSAYS: ON

ESSAYS: ONTOLOGY AND AGENCY OF DATA [INFRASTRUCTURE]

FROM DATA CENTRE TO

FROM DATA CENTRE TO DATA FOREST

Marina Otero Verzier

Imagine walking through a park. A park that is actually a library. Where every flower, plant and shrub is a data archive. As you sit down on a bench and touch a leaf with your portable reader, you start listening to the Rolling Stones, the music coming directly from the information stored in the plant's DNA. Later, amid the greenery, you read a novel or watch a documentary.[1]

Cartesian Enclosures

Envisioning futures is not as easy as it might look. The 'defuturing' processes (as coined by design theorist Tony Fry) and the slow cancellation of the future (as argued by author Mark Fisher) of capitalist patriarchal modernity have created an unliveable world for humans and non-humans.[2] Despite the fact that other paradigms are urgently needed, however, too many of us have lost our ability to imagine alternatives. We are subjected to an appalling sense of exhaustion and finitude and too often driven by inertia.

That is not the case of Karin Ljubič Fister, a doctor and genetic researcher from the University of Maribor (Slovenia), whose curiosity for storing binary data in the DNA of plants and seeds engendered a radical vision for data centres. According to Fister, by containing information—be it an image, a song, a book, a drawing—in every cell of the host organism, billions of gigabytes of data could be archived for millennia and possibly beyond—and without the human. Despite unavoidable controversies surrounding biotechnology and genetic-engineering experiments, and the difficulties of materializing this alternative data storage, Fister's project allows architecture to be imagined differently. In particular, it opens up the possibility of a future for the architecture of data centres that goes beyond Cartesian logic.

As a philosophical and scientific system founded by René Descartes (1596–1650), Cartesianism developed around the prerogative of 'mind over matter'. By refusing to attribute a soul—reason—to animals and plants, Cartesians rendered humans unique beings, separated from the rest of nature and occupying a superior position in relation to others.[3] The human, and particularly the Western white man, was then constructed as a universal, rational subject, entitled to dominate the landscape, resources and other beings. This categorization of beings, and the compartmentalization and instrumentalization of human and non-human relations, subsequently enabled the discrimination of entities, bodies and identities for the benefit of that particular human.

Enmeshed in the space we continue to inhabit, Cartesian dualisms are at the core of the discipline of architecture. They define what I call the 'Cartesian enclosure', a controlled space, shaped by technological rationales, coalescing in unassuming architectures organized according to borders that neglect the surrounding environment. Supporting Western man's exceptionality, these architectures follow economic efficacy rationales and extractivist logics, often at the expense of ethical and ecological awareness.[4]

Data centres are one of the most recent exponents of the 'Cartesian enclosure'. A central piece of today's political, cultural, socioeconomic system, data centres mediate the creation, storage and transmission of digital records across physical networks. Their functioning, however, involves vast energy and water consumption, land occupation, large global carbon emissions, and is reliant on extractivist practices.[5] In Fister's imagination, though, data centres transfigure into a spatial and material entanglement difficult to describe under dual, Cartesian categories: a more-than-human architecture, non-contained by walls, non-dependent on fossil fuels, efficacy or productivity, and not propelled by the punitive work of 'the other'.

DNA Data Storage

Even if easily categorized as science fiction, the plant-DNA architecture described by Fister is an alternative worth pursuing to tackle the unprecedented worldwide demand for data storage and its ecological footprint. As humans continue to generate and consume more and more data, the digital-data production is outpacing the scalability of today's storage solutions. According to International Data Corporation (IDC), data generated globally will grow by 23 per cent annually from 2020 to 2025, reaching 180 zettabytes in 2025.[6] The developments in AI, the Internet of Things and the Metaverse, which demand vast amounts of data to be stored for extended periods, will only exacerbate this condition. Gartner, in its report 'Market Trends: Evolving Enterprise Data Requirements', refers to a coming Zone of Potential Insufficiency and estimates that hyperscale vendor data-storage demand, which grew by nearly 35 per cent CARG (Compound Annual Growth Rate) from 2013 to 2019, could potentially soar to 50 per cent CARG from 2020 through 2030.[7]

Following these estimates, growth appears to be the only available option, even in the face of climate catastrophe. Growth, these reports strategically insist, is inevitable. And by disregarding the possibility of data production and consumption behaviours that reduce dependence on data centres, these statistics push governments and the industry to find new technological fixes rather than conceive other forms of living. In this context, data centre architecture has turned into a critical site of investment and innovation. Unsurprisingly, the largest commercial real estate services company in the world, CBRE, has recently launched a data centre division, while architecture and engineering firms such as Corgan, HDR, Gensler, AECOM and Arup are also expanding their operations.[8]

And yet, the architectural solutions for reinventing these facilities fall short to the point that the Metaverse cannot be delivered without a planetary meltdown. While most digital infrastructure providers experience difficulties coping with demand, environmental targets, governmental bans and regulations, industry conglomerates are taking the opportunity to invest in stable and scalable data-storing mediums not dependent on copious energy, water and land consumption. Molecular and biological computation are among the thriving methods praised as a solution to the shortcomings of current storage models. Their implementation is opening previously inconceivable (and convoluted) futures that reach beyond the existing architecture of data centres.

In Cambridge, Massachusetts, the Whitesides Research Group is experimenting with fluorescent dye storage.[9] Microsoft's Optics for the Cloud group at the Microsoft Research Lab in the UK recently launched Project HSD, which focuses on hologram data storage, and Project Silica, which studies the capacity of crystals to deliver long-term archival storage.[10] Companies, including Illumina, Microsoft and Twist, have created the DNA Data Storage Alliance to develop DNA-based data storage solutions in California. They propose DNA data as a long-term, reliable and ecological alternative to tape drives or HDDs.[11] Professor George Church is carrying out similar work at Harvard's Wyss Institute in Cambridge.[12]

In 2013, building on these studies yet embracing a different ethos, Karin Fister and Iztok Fister Jr conducted tests using plant-based DNA as a storage medium. Their experiments instigated the image of the data forest we walked through at the beginning of this essay. As Karin explained in an interview with *New Scientist*, the idea was born out of frustration with the continuous lack of disc space on her computer and the determination to find an alternative system.[13] Aware of the compatibility of genetic programming and binary code, she wondered if plant DNA could also be used as a storage medium. Together with colleagues at the university, Fister inserted a basic computer program called Hello World into a tobacco plant's DNA. The sequence of 0s and 1s was translated into artificial DNA by turning 00 into A, 10 into C, 01 into G and 11 into T. Upon synthesizing the resulting DNA sequence, the team transferred the DNA into a bacterium with which they infected one of the plant's leaves. They later took a fragment of the infected leaf, planted it, and grew a tobacco plant whose leaves, seeds and future offspring contained the Hello World program encoded in their DNA.

The research success encouraged Karin Fister and Iztok Fister Jr to publish the paper 'How to Store Wikipedia into a Forest Tree: Initial Idea' (2014). By storing information in the DNA of plants and seeds, the Fisters proposed creating off-the-grid, living Wiki forests that capture CO2 and produce oxygen.[14] The project had revolutionary potential. Yet, while the encoding process was successful, the data stored in the DNA was read-only, preventing users from editing entries.[15] Proving the system was better suited to archiving did not impede the Fisters' ambition. Rather the opposite. 'All of the archives in the world could be stored in one box of seeds,' Karin stressed.[16] And, just like that, by scaling up the operation from a box of seeds to a collection of them (similar to the Svalbard Global Seed Vault), the Fisters envisioned no less than an architecture in which to keep all the world's information.[17]

Still, understanding seeds as storing drives and plants as data archives implied the possibility of data retrieval. According to Fister, the extraction of the plant's DNA and sequence could be carried out using standard methods and specialized botanical equipment, although it would involve the destruction of some leaf material. As DNA encoding and retrieval technologies evolve, Fister anticipated, they could decrease costs and production time and avoid the living organism's damage during the process. In the meantime, until such technologies are widely available, the seeds-drive could be frozen and have their germination ability preserved for millennia.

Beyond Technological Fixes

Fister's work has important implications for the relations between data storage and the environment. Whereas their latest proposal still considers architecture as a stable container—a seed vault—it unleashes the architectural imagination, making it possible to conceive of alternative spatial, non-Cartesian worldmaking models. There are troubles in paradise, however. Whereas DNA data storage solutions may challenge aspects of the Cartesian enclosure, the system still requires the modification of living organisms. Commercially driven applications often treat plants and, in particular, their DNA as a resource to be extracted and unproblematically subjected to human utilitarian needs, triggering ethical concerns about the exploitation of beings on the grounds of human's benefit and exceptionalism (which, as we have seen, lies at the core of Cartesianism).

At the same time, the narratives surrounding this technology's market application assume the inevitability of growth and the role of the planet as a resource to meet human's compulsive and devastating desires. They propose, as researchers and scholars Madeleine Mendell, Mél Hogan and Deb Verhoeven have argued, a frictionless storage medium for a limitless accumulation, possibly beyond the human: while most forms of life on the planet may be wiped out due to climate catastrophe, human information will survive.[18]

Rather than attempting to address both the need for storage and the environmental collapse by adopting alternative data-production and storage practices, scientists invest in technological fixes imbricated in apocalyptic thinking.[19] Fixes such as genomics research and synthetic DNA that, as Hogan reminds us, depend on a profit-driven system and a global communications infrastructure and computational power reliant on exploitative logics: cheap labour, extraction of natural resources, and proprietary software and hardware. Driven by a fear of extinction and loss, these scientific, market-driven remedies hold an empty promise of keeping information unaffected by the passing of time. But they fail to acknowledge that any archival holding is continually renewed through practices of maintenance, that meanings are transformed as they are continually performed and that remembering simultaneously concerns knowledge generation and its loss.

By contrast, non-industry examples conceived by Karin Ljubic Fister and others offer generative ideas based on scientific realism and speculative design that account for the environmental impact of DNA-based infrastructures, but also the poetics and politics of storing and preserving.[20] They prompt world makings that understand data storages as archives enmeshed in states of proliferation and decay. Preservation processes that recognize memory not as what is contained and stored, but as a dynamic practice that involves acts of remembering and forgetting.[21] Through states of gradual decomposition and recomposition, what is archived generates future meanings that exceed the intentions and interpretations of those who deposited and contained it.

The data garden is one of these futures. Conceived by Grow Your Own Cloud (GYOC), a duo formed by Monika Seyfried and Cyrus Clarke, the data garden transcends the notion of a repository of seeds and proposes a dynamic system.[22] One made of plants carrying our more precious memories. One that turns plant caring in our domestic spaces, at a community flower shop, in a public garden or a forest, into a collective and more-than-human memory-making practice. And, perhaps more importantly, one that challenges architecture's Cartesian postulates and their imperative of rationalization. Instead of the conventional stable form of the black box storage, the resulting data garden is an information ecosystem that transforms solar energy into living matter, captures CO2 and creates oxygen. This architectural assemblage of space, data and organisms, grows unpredictable environments, structures and relations that surpass discrete forms of being, their meanings and knowledge.

In considering plant DNA data storage as a generative idea, however, ethical questions arise. What is at stake when we encode human data in the DNA of a plant? How can an ethical human-vegetal engagement be established that also speaks to climate justice? And which theoretical framework would help define the resulting knowledge from the melding of human and plant thinking?

Plant Intelligence and Ethical Conundrums

As professor of philosophy Michael Marder argues, research on plant intelligence carried out over the past three decades questioned traditional understandings of vegetal life and, with them, previously held moral stances.[23] Critical plant studies have unleashed theoretical arguments and experimental evidence on the state of plant existence that challenges Cartesian postulates, destabilizes Western philosophy's treatment of plants and supports the idea of plant intelligence.

Marder is one of those arguing for the recognition of the multidimensional intelligence of plants. The imageless and non-representational material memories stored in the plant's cells are, according to him, constituents of the 'non-conscious intentionality'.[24] A kind of 'thinking before thinking', evident in plants striving towards the sun, their roots seeking nutrients in the soil and other actions that demonstrate their creative interaction with their environment. This intentionality in plants demands human's acceptance of 'the ontological fact that they exist neither for human enjoyment and consumption, nor for the sake of anything or anyone'. An acknowledgment that could bring about a renewed and reciprocal relation between humans and plants. A relation receptive to plant's otherness and, as such, not organized around the benefit of the human nor the calculative rationality of capitalism, but based on solidarity and cohabitation.[25]

In the context of the data forest and data garden, to counter extractivist logics implies, following Marder's argument, resisting its conceptualization around instrumental rationality and, instead, establishing a human-plant creative relation of knowledge co-production and communication. Rather than controlling and dominating plant behaviour to preserve information and treating plants as resources to be exploited, humans should respect their ontological freedom and let vegetal beings be. This 'letting be' implies preserving their wilderness—vegetal wilderness as a category constructed in opposition to plant cultivation and genetic engineering for the sake of efficiency and profit.[26] For it is precisely the appeal of monoculture (and the selection of plant species on the basis of their DNA-storing capacities) for optimizing the system that the project ethos contests. In addition, 'letting be' also demands preserving plants' existential potentialities, including their 'reproductive capacity and, hence, futurity'.[27] Whereas the deployment of a plant's genetic modification has been a common design practice resulting in patented seeds with a very limited lifespan—ensuring continuous demand and hence revenues for the corporations holding their patents—the data forest and data garden aim to support non-proprietary futures for plants and other beings on the planet.

Having reached this point, we should also scrutinize the possible effects of encoding data on plants. A site of material memory, the body of plants is a receptive medium that channels energy and registers an incredible biological hospitality.[28] It is, as is visible in the rings of a tree trunk, an embodied spatiotemporal archive of their vegetal memory and the physical stimuli that have affected them.[29] For the subjectivity of plants is distributed throughout their bodies, from the roots to the leaves. Might the encoded data therefore radically transform their way of being?

Plants have, in fact, an extraordinary capacity for regeneration and for making use of that which otherwise could be a threat. The fact that they exhibit 'growth by increments, quantitative additions, or reiterations of already existing parts' makes plants resilient against external factors and alterations, but will inevitably also affect the stability of the information stored.[30] While these processes of information altering render plant DNA storage unsecure for commercial enterprises that prefer, instead, to focus on ungerminated seeds as storage medium, the relevance of the forest data relies precisely on coming to terms with the prospect of plants exceeding the frameworks we set for them. That is, recognizing and celebrating their autonomy and embracing a human-plant communication beyond commodification and the mere circulation of information through digital bytes.

As plants germinate, grow, multiply and even repair their DNA without human aid, encoded human data would not stay unchanged. Errors and mutations would alter the code over time, leaving room for unexpected developments—entanglements of matter and data that resist utilitarian motivations and surpass and exceed human intentions and memories. Even more, by resorting to the Socratic analogy between bodily generation and the birthing of ideas, it is possible to argue, as Marder does, that these developments and material reproduction happening in the plant's body are a prototype of thought. An intelligence that transcends human's narrow conceptions of thinking and produces new knowledges and meaningful material enmeshments. Resulting vibrant entanglements and, why not, aberrations, transcend any purpose apparent to humans without necessarily making them meaningless or irrelevant.

In the data forest, plants won't only keep, but also rewrite human knowledge, opening cracks in the Cartesian logic and its historical living beings' divide.[31]

The Annihilation of the Line

What, we should ask, does this mean for the discourse and practice of architecture? A grid of computer server racks, data halls and high-density PODs generally organize the architecture of the data centre. Systems controlling temperature, humidity and dust ensure their smooth operation. Fibreoptic cables connect data centres with users at the speed of light across the entangled geographies of mining sites, factories, ports, switch-points, mobile telephone towers and the space of everyday life.[32] Yet, despite their enmeshment with multiple sites, scales and times, most data centres are conceived as rectangular black boxes.

Whereas the environment is in a constant state of emergence, the discipline of architecture has been largely founded on the model of solids and the Cartesian paradigm. The Western architectural canon is organized according to solids geometry and the Cartesian grid. The latter, a coordinate system and seemingly neutral method for categorization based on X, Y and Z axes, and one of Descartes's most important legacies, enabled the rationalization of space in order to visualize, calculate, draw, optimize, replicate, standardize and, ultimately, control it.[33] The Cartesian grid organizes the Cartesian space, where humans position themselves as separate from the environment, often in a hierarchical, antagonistic position. A position from which to seek their survival and dominion over the medium at any cost, even at the expense of the entire planet.

If the discipline of architecture asserts the separation of human and non-human, plant-thinking implies, in contrast, an entangled, embedded, non-appropriative, non-dominant relation between living organisms and the environment. Plants are, according to Marder, 'guarantors of environmental justice', as 'the vegetal *it thinks* will moderate the lethal tendencies of the human *I think*'. Plant-thinking disregards metaphysical distinctions between plants, animals and human beings, and goes beyond the fictitious enclosure of a reified and self-sufficient identity. In doing so, plant-thinking helps to imagine a data centre that is more than a repository of information. It allows us to see it as an architecture of evolving forms of materiality in time and space, where plants are agents responsible for material changes (including modification, decomposition, disintegration), where not all information is extractable textual or graphic human knowledge, where loss is an inevitable condition for transformation and forgetting is inseparable from remembering.

Marder's unpacking of plant-thinking shows the way for architecture to be conceived otherwise. So do Marisol de la Cadena's theories on indigenous political strategies. Equally not bound by binary logic and Cartesian categories, De la Cadena's work invites us to slow down our practice of knowing the world and the organisms that constitute it,[34] to embrace worlds embodying immeasurability and mutual difference. By suspending the compartmentalization of the world and exceeding the categories that we mobilize to know it, De la Cadena explains, we could instigate worlding practices and futures based on mutual care, empathy, life-in-common. In embracing the spaces and ways of being of the 'between', and the 'be with', plants are plants *but not only*. Humans are humans *but not only*.

Marder and De la Cadena's theories help to muddle the lines that have long fortified the Cartesian divide; lines blurred in the architectures proposed by Fister and the GYOC that spark the imagination of what the architecture of a data centre, a library, an archive, a museum or a school could be. Despite many unsolved questions regarding the data forest and the set of rituals and power relations that might take place there (ownership, political context, status and provenance of the encoded information, conditions under which the information is accessed and decoded, etcetera) it provides an image and metaphor of a non-Cartesian architectural space. That is, an architecture inseparable from its environment, where the building and the documents stored are entangled in a spatial system that germinates, blooms, flourishes. A contingent, temporary assemblage of living matter. A place shared by all living beings and not defined by distinctions, categories and hierarchies, but by trans-species interactions. A space of inhabitation and knowledge-sharing not based on containment, not defined by walls. A spatial system that grows slowly and opens previously inconceivable futures. That is orchestrated to serve the many and is the result of a multifarious agency instead of a discrete set of designers. That exists in continuity with the environment. That is both alive and gives life. That makes breath possible. An architecture that breathes and is breathed. That changes our affective relation to others and the world.

Imagine walking through a forest. A forest that is actually a library, a school, a museum. Where every tree, flower, plant and shrub is an archive and an architecture of generative flourishing. As you stop amid the greenery and touch a leaf, you attune to previously unimageable worlds. Worlds far away from the myths of immortality. Far from the defuturing effects of the Cartesian enclosure, and the false promises of endless growth.

Notes

1 Sean O'Neill, 'Imagine Storing All the World's Archives in a Box of Seeds', *New Scientist* (13 January 2016), https://www.newscientist.com/article/mg22930560-400-imagine-storing-all-the-worlds-archives-in-a-box-of-seeds/#ixzz7PVJsrePH.

2 Tony Fry, *Defuturing: A New Design Philosophy* (London: Bloomsbury Visual Arts, 2020). See also: Arturo Escobar, *Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Words* (Durham, NC: Duke University Press, 2018), 16–17; philosopher Franco 'Bifo' Berardi coined the phrase 'the slow cancellation of the future' in his book *After the Future* (2011) to describe the postmodern condition. Cultural theorist Mark Fisher mobilized this notion to explain the deflation of expectations as a result of neoliberal capitalism and the inability of contemporary cultural production to came up with anything genuinely new, a symptom of the impossibility of imagining a better future or a world beyond our own.

3 Cartesianism, its imperative of rationalization and theory of the animal-machine, drove the mechanical age and the formation of Western capitalism. Influenced by the technical creations of the early seventeenth century, its founder René Descartes (1596–1650) referred to machines as models to explain the functioning of organisms in what came to be known as the Cartesian theory of the animal-machine. Departing from the observation of the parallels between animal movements and automatic mechanical movements (early machines were necessarily powered by humans or animals), Cartesians attempted to explain physical and biological phenomena solely by technical models. See also: Georges Canguillhem, 'Machine and Organism', translated by Mark Cohen and Randall Cherry, in: Jonathan Crary and Sanford Kwinter (eds.), *Incorporations* (New York: Zone Books, 1992), 52.

4 See Marina Otero Verzier, 'Cartesian Enclosures', *New Geographies* 12, 'Commons', edited by Mojdeh Mahdavi and Liang Wang (March 2022), 39–57.

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10 'Project HSD: Holographic Storage Device for the Cloud', *Microsoft.com*, https://www.microsoft.com/en-us/research/project/hsd/, accessed 2 February 2022; 'Project Silica', *Microsoft.com*, https://www.microsoft.com/en-us/research/project/project-silica/, accessed 2 February 2022.

11 'Preserving our Digital Legacy: An Introduction to DNA Data Storage', first whitepaper published by The DNA Data Storage Alliance, *DNA Data Storage Alliance website*, https://dnastoragealliance.org/dev/wp-content/uploads/2021/06/DNA-Data-Storage-Alliance-An-Introduction-to-DNA-Data-Storage.pdf, accessed 3 January 2022.

12 'DNA Data Storage: Integrated Information Storage Technology for Writing Large Amounts of Digital Information in DNA Using an Enzyme-Driven, Sustainable, Low-Cost Approach', *Wyss Institute Harvard website*, https://wyss.harvard.edu/technology/DNA-data-storage, accessed 2 February 2002.

13 O'Neill, 'Imagine storing', op. cit. (note 1).

14 Karin Fister and Iztok Fister Jr, 'How to Store Wikipedia into a Forest Tree: Initial Idea', paper first delivered at the Conference Multimedia, Scientific Information and Visualization for Information Systems and Metrics (MSIVISM 2014), Maribor, Slovenia, 29–31January 2014, http://www.iztok-jr-fister.eu/static/publications/35.pdf, accessed 5 December 2021.

15 Ibid.

16 O'Neill, 'Imagine storing', op. cit. (note 1).

17 Ibid.

18 Madeleine Mendell, Mél Hogan and Deb Verhoeven, 'Matters (and Metaphors) of Life and Death: How DNA Storage Doubles Back on Its Promise to the World', *The Canadian Geographer* IF1.5 (11 January 2022), 46.

19 Mél Hogan and Deb Verhoeven, 'Sustainable DNA: In Conversation', in: *Right Research: Modelling Sustainable Research Practices in the Anthropocene* (Cambridge: Open Book Publishers, 2021), http://books.openedition.org/obp/20563.

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23 Michael Marder, 'Is It Ethical to Eat Plants?', *parallax* 19/1 (2013), 29.

24 Michael Marder, 'What Is Plant-Thinking?', *Klesis, Revue Philosophique* 25, 'Philosophies de la nature' (2013), 125.

25 Marder, 'Is It Ethical', op cit. (note 23), 31.

26 Ibid., 34.

27 Ibid.

28 Ibid., 33.

29 Marder, 'What Is Plant-Thinking?', op. cit. (note 24), 126; see also: Marder, 'Is It Ethical', op. cit. (note 23), 33.

30 Marder, 'Is It Ethical', op. cit. (note 23), 36.

31 See: Marina Otero Verzier, 'Cartesian Enclosures: From Grid to Cloud', *Archined*, 'The Persistence of Questioning' (December 2021), https://www.archined.nl/2021/12/cartesian-enclosures-from-grid-to-cloud/.

32 Analysing the material implications of data infrastructures was one of the aims of the architecture studio ADS8: Data Matter: Digital Networks, Data Centres & Posthuman Institutions, led by Kamil Hilmi Dalkir, Marina Otero Verzier and Ippolito Pestellini Laparelli at the Royal College of Art in London, https://www.rca.ac.uk/study/schools/school-of-architecture/architecture/ads-themes-2019–20/ads8-data-matter-digital-networks-data-centres-posthuman-institutions/.

33 Descartes introduced the Cartesian Grid in *Discourse on Method* and more precisely in one of its three appendices titled *La Géométrie*, published in 1637. The system makes it possible to specify the position of any point or object on a surface using two intersecting axes as measuring guides, and to exactly duplicate geometric figures.

34 See: Marisol de la Cadena, *Earth Beings: Ecologies of Practice across Andean Worlds* (Durham, NC: Duke University Press, 2015).

VIBRANT DA

VIBRANT DATA: THE SEWER AS INFORMATION INFRASTRUCTURE

Sabrina Chou

(An Archaeology)

This is a transcription of social movement and the transmission of bodies, complete and incomplete. It is a record of circulations past and present. It moves at the horizon between political techniques of objective totalization and technologies of subjective individualization, and their expressions through code and protocol on the one hand, and desire and consumption on the other.[1] A peristaltic—and thus moving, changing—image of the social, through the sewer.

This is a reading of excrement through theories of information.[2] It is a materialization of flows of information and social circulations of belief and desire. To excavate the sewer as a site of vibrant[3] data is not only to contend with millennia of civilizations built and eroded, or with the management of bodily fluids, disease and populations, but it is also to confront a symbolic structure of the state form,[4] and the convergence in contemporaneity of a high-speed networked global economy with the slow-moving sludge of bodily waste. It is an archaeology that peers into the depths of our own ex-embodied excreta. But rather than suspending excrement in a realm of abject self-alienation,[5] this study recuperates our shit to reveal the glimmers of its potency in historical and contemporary fertilization and medicinal practices, as well as its potential as a source of collectivized data. Reading shit in this way has implications for an embodied (meta)physical approach to data as a social substance. This is not to say that we must instrumentalize and capitalize on even those residues of excrement that are passively produced by the shared labour that is our digestion.[6] Instead, what we trace here is a 'zone of irreducible indistinction', indeed, a zone of biopolitics that can—and must—be extricated from the realm of semiotic biopower and quantifiable code.[7]

By bringing together the recent use of sewage surveillance for public health and Covid-19 monitoring with the installation of fibreoptic data cables in existing sewers, I propose a reconsideration of the metaphysics of data that gestures towards a communal and biosocial understanding of information. The vibrant data of the sewer might revitalize the notion of the multitude via Gabriel Tarde's concept of the microsocial, tracing the flows of the social through the dynamic material flows of the sewer and the coded informational flows of the fibreoptic cable. In Tarde's theory, the binary of individual versus collective is set aside for the concept of the microsocial, in which social flows—beliefs and desires—are in motion, aggregating into social forms like institutions.[8] The notion of vibrant data might also reveal a semantic valence of biopolitics, one that can offer a mode of engaging information that refuses immediate reduction to positions of greater or lesser value and instead attends to the contextual, relational aspects of transmission and communication. Can we treat the use and study of data not as individualized points of consumer preferences or overcoded collective masses, but instead as sets of social flows that produce and allow for multiple and overlapping meanings?

In foregrounding the sewer as an infrastructure for the circulation of information, perhaps we can better understand collective pictures of local, communal microbiometrics, their correlations with ecological factors and their implications for public health. By acknowledging the vibrancy of data and its relational status, perhaps we can also shift our notions of public and collective, of life and matter, of how the social forms and flows—even in the bowels of our cities.

Viral Data: Biopolitics of the Sewer

In *History of Shit*, Dominique Laporte describes the institution of protocols around hygiene, including the handling of all manner of waste and the building of cesspools in the year 1539 in France. In the same year, these hygienic codes collided with an edict establishing the official language of France, thus unifying and reinforcing the power of the monarchy. Together, these protocols, where shit and language coincide, can be read as a registration of the idea of the nation-state.[9] Here, base bodily function meets with the establishment of the institution of language—which might be considered the basis for and which makes possible political life.[10] Giorgio Agamben describes biopolitics as the 'zone of irreducible indistinction', where bare life and political life, where inside and outside, can no longer be separated. He calls for a new politics to be invented.[11] Why wallow in the sewage of our already existing present? The sewer is a site for the collision of bare life and political life. What has historically been an infrastructural necessity has become once again an index of the biopolitical.

The Covid-19 pandemic has created new global circumstances that have demanded large-scale responses and technological developments at a previously untested scale and speed. The pandemic has brought with it new governmental protocols, social behaviours and economic problems. One of the innovative by-products of the pandemic has been the initiation of sewage surveillance, which studies and monitors the prevalence of the SARS-CoV-2 virus and the RNA of specific virus strains in sewage.[12] For example: the National Institute for Public Health and the Environment of the Netherlands first monitored sewage from Schiphol Airport in mid-February 2020 and has now partnered with the 21 regional water boards of the country to monitor all of the more than 300 sewage treatment plants in the Netherlands for SARS-CoV-2 virus particles.[13] In the United States, the Centers for Disease Control and Prevention and the US Department of Health and Human Services initiated the National Wastewater Surveillance System to understand the prevalence of SARS-CoV-2 in local communities.[14] In the UK, the Health Security Agency has started testing for SARS-CoV-2 RNA in the Environmental Monitoring for Health Projection wastewater programme, taking samples from sewage treatment works and sewer network sites.[15]

Sewage surveillance can provide a collective picture of the scale of infection in a community or communities, even when virus symptoms are not present or when testing is unavailable or not used. Sewage surveillance can thus provide local health administrators and citizens with early warnings of possible spikes in infection localized in particular communities, prior to detection through testing or clinical presentation. Importantly, sewage surveillance is not dependent on behavioural compliance or changes in policy. It is based on the bare, material fact of regular bodily functions. These sewage surveillance programmes have potential uses in other public health initiatives—for studying populations and their health, or for looking at broader ecosystems and watersheds and the effects of climate change on them. For instance, sewage and wastewater surveillance has been used to monitor other viruses, such as noroviruses, hepatitis E and polio; to examine antibiotic resistant bacteria or antimicrobial resistance; to monitor spatial and temporal trends of recreational, illicit and pharmaceutical drug use on local and international scales; and to monitor the presence and possible ecological effects of microplastics in wastewater.[16] Collecting excrement and studying it has become a source of vital information about local public health.

Shit itself is vital. Humans have long used the excrement of both humans and animals as fertilizer. Consider, for example, the pigeon towers of Isfahan, which were built solely to house pigeons and their excrement to be used as manure.[17] More recent initiatives have returned to ancient practices of converting human faeces into fertilizer to deal with waste accumulation while nourishing poor soil, or to process excrement for use as fuel after removing water and sanitizing it.[18] We use excrement now not just to fertilize land or to burn as fuel, but also to support life and living. Recent research into the gut microbiome and faecal microbiota transplants has made this more urgently evident. Jane Bennet has written about tracing chemical exuberances through bodies and sites, and Michelle Murphy about how microbiome research reveals that humans are collectivities, rather than discrete, contained bodies.[19] Studying the microbiome has made clear that our bodies are not singular, but instead always already irreducible and ungraspable multiplicities. Microbiomes are not bounded within the confines of our bodies, but instead spill over and out, commingling to produce new ecosystems, relations and assemblages. But while these studies are applicable on the level of broader populations, the use of faecal matter in faecal microbiota transplants is still individualized, on a one-to-one, bowel-to-bowel basis. The *United European Gastroenterology Journal* specifically states that:

> Pooling (mixing) of multiple donor faeces during processing is not recommended because: (a) it hampers the traceability of the faecal preparation to the individual donor; (b) the risk of transmissible disease may be increased; and (c) the principle of transfusing a balanced microbiota preparation may be lost.[20]

Ancient historical practices, while perhaps failing to meet present-day medical and hygienic standards, might point to more collective and communal uses of faecal treatments. For instance, even as early as the fourth century CE, ancient Chinese medical texts refer to cures for the treatment of food poisoning, severe diarrhoea and otherwise incurable conditions with various faecal or fermented faecal treatments administered by mouth and otherwise, including the sealing of liquorice root in bamboo that was left in a village latrine for a year, then retrieved and ground up for poultices or other therapies.[21] Such approaches demonstrate the basis for a social and local use of faecal matter, for a socially and locally situated understanding of the internal microbiome and its co-constitution with, by and of local, social, bodies.

As individuals, we are necessarily and urgently situated in an environment, within an ecological assemblage of other humans, of networked communication, of macro-watersheds and of the microbial matter that co-constitutes our bodies. Locality matters here. Methodologies can be translated and scaled up or down, but it matters *whose* shit is mixing *where*. The vitality of our sewage, which is teeming with microscopic life—with the diversity of microbiotic bacteria and viral RNA, next to traces of environmental chemical leakages and the residues of microplastics that have also journeyed to and subsequently through our bodies—points much more to *multitude* and crowd than to the sewer's ancient architectural symbolic status of *civilization*. Michel Serres has written about the crowd and its solidification into institutions or foundations: 'The crowd is fluid. An institution stable, is solid. The foundation solidifies the crowd.'[22] Attending to the biopolitics of sewage and its data re-liquifies such solidified crowds into fluidities, into flows, into multitudes.[23] These are crowds and pluralities that exist in a state of multiplicity and motion, where they are not unified or homogenized and thus are not (yet) objectified into a people or a collective subject of the state. In *The Grammar of the Multitude*, Paolo Virno writes about Spinoza's concept of the multitude, wherein 'the *multitudo* indicates a plurality which persists as such in the public scene, in collective action, in the handling of communal affairs, without converging into a One, without evaporating within a centripetal form of motion.'[24] A centripetal form of motion focuses on a singular, central point, bringing everything together into a simultaneity, at the same speed and in the same direction. But the multitude flows freely, retaining a plurality of possible directions. Virno describes multitude as 'the form of social and political existence for the many, seen as being many'.[25] The multitude is the crowd before it becomes a people, an addressee or a targeted collectivity. It is this 'many, seen as being many' that is in dynamic motion in the circulating excrement—and chemical, biological and ecological information—that flows through our sewers. The sewer, then, or the lower stratum of the built and inhabited environment, is where the material substance of the multitude flows, alongside its potency as a streaming source of viral, vital data.

If the biopolitics of the sewer speaks multitudes, what else can we find as we trace the moving contents of these social infrastructures?

Digital Waste: The Sewer in the Information Age

Excavating sewers reveals much about the societies that built them. They are archaeological evidence of feats of engineering and can trace histories of urban development and morphology. The contents of sewers reveal the social histories of a particular group of inhabitants, as much about cultural dietary practices as about differences in socioeconomic class.[26] In 'Deep Time of Media Infrastructure', Shannon Mattern describes how our infrastructures—and in particular, infrastructures of communication—are layered over time, rather than merely replaced or phased out.[27] The sewer presents itself as such an infrastructure that layers large-scale hygienic utilities with communications infrastructure: next to excrement, sewers also host fibreoptic cables that are installed there to avoid the expense, disruption and sometimes destruction of digging new tunnels under cities. Like excrement, which has long been sequestered underground, data cables are not ordinarily visible or present. Nicole Starosielski locates the invisibility of cable systems within 'a broader social tendency to overlook the distribution of modern communications in favour of the more visible processes of production and consumption' rather than 'any intentional desire to obscure cable systems'.[28] Making visible such communication distribution systems might be akin to attending to the concealed bodily processes of digestion and excretion that have long been ignored or overlooked in light of production and consumption.[29]

A closer look at the layered infrastructures of the sewer and the data cable shows a pragmatic coupling of the two. The use of existing infrastructure like sewers and pipes for the installation of fibreoptic cables offers financial benefits, as well as the possibility of monitoring the—often aging—infrastructures for leaks during installation.[30] The first instance of installing fibreoptic cables in existing sewers was in the United Kingdom in 1984, by the Water Research Centre.[31] Since then, different techniques have been implemented globally for installing fibreoptic cables in sewers. While early methods used robots and drill and dowel techniques, other methods include the implementation of cabling trays, or the installation of lining systems that simultaneously fortify deteriorated sewers and provide protective housing for cabling.[32] Fibreoptic cables continue to be installed in sewer lines, especially in ongoing efforts to rapidly extend broadband capacity to more and more users, particularly those outside of more densely inhabited metropolitan areas.[33] The sewer has thus become part of the conduit system of networked infrastructures that produce and circulate social media, platform-based economies and new financial instruments.

This convergence of the network and the sewer—or, the network *in* the sewer—brings the material and immaterial multitude together. The mingling of bodily and disembodied activity also muddles the already blurred boundaries of public and private. Tung-Hui Hu compares the privatization of the Internet following its initial design and usage via time-sharing to the privatization of hygiene via the sewer system: 'Centuries before computers were invented, sewers kept each household's private business private even as it extended the armature of the state into individual homes.'[34] While the sewer was designed to keep the waste of individuals private, opening up the sewer as a vital source of social data might be able to de-privatize human functions both excretal and digital.

Subterranean fibreoptic cables carry new products of biopower: digital waste and data collected from our content production and consumption; violent, digital pollution that is cleared by the invisible labour of content moderators; and platform-mediated, network-based economic exchanges. The data cable is a part of a larger network of the Internet of things through which soft pollution—disembodied waste and its biopolitical affects—circulates. In the sewer, we come to find the circulation of multiple streams of excreted and expelled vital data. While there are myriad ways to analyse data and its social effects, one mode of analysis might point to Gabriel Tarde's early description of social flows as *beliefs* and *desires*.[35] In fact, these elements are perhaps some of the most valuable data currently collected and analysed. Marketing to beliefs allows for the shaping of political views, opinions and even electoral outcomes, and marketing to desires generates advertising revenues, optimized product development research and increased sales.[36] Might it be possible that beliefs and desires are some of the most instrumentalized aspects of digital activities? The profiles that are created from the traces of our digital activities—the digital traces of our beliefs and desires—'produce estimating patterns and anticipate potentialities: consumption preferences, economic value, behavioural inclinations, professional capacities, virtual diseases, political preferences.'[37]

The content and composition of our collective excrement can also be studied in terms of their material manifestation of desire and belief. The consumption of food, pharmaceutical and recreational drugs, and other substances are often tied to our corporeal desires and structures of belief, whether rooted in religious observance or within a body of sociomedical knowledge. Agamben writes about the term *diet*, wherein maintenance of life coincides with a regulatory and formal process. The ancient medical term *diaita,* he writes, 'designates the regime of life, the "diet" of an individual or a group, understood as the harmonic proportion between food (*sitos*) and physical exercise or labour (*ponos*)', while also being the term for 'arbitration that decides a suit not according to the letter of the law but according to circumstances and equity'.[38] The term has further developed to mean 'a political assembly with decision-making power'.[39] As both 'mode of life' and the 'governance and regime of life', *diet* thus regulates the body at the intersection of the biological axis and the political axis of life and living.[40] Along these lines, we find that code and protocol, expressed through both digital activity and dietary practice, circulate the social through the sewer. What are the biopolitical implications of these sociopolitical flows, if we are not to be completely and immediately reduced and subsumed to mechanisms of capitalism as units or profiles of consumer and consumption? How might the multitude and the beliefs and desires—the excremental traces of data and digestion—that move and make the social offer another perspective, another possibility for life and living?

The confluence of digital and dietary waste in the sewer points to a composite notion of sociality. Rather than thinking through the binary of individuals versus collective mass, it might be helpful to turn to Fernanda Bruno and Pablo Manolo Rodriguez's theorization of a 'complex dividual-individual composition' that is constituted via 'biotechnologies, digital culture, and financial capitalism' and its appearance via biogenetics, digital profiles, mobile applications, wearable technology or financial subjects.[41] According to anthropological perspectives, and as described by Marilyn Strathern in her discussion of Melanesian persons and personhood, the dividual contains 'a generalized sociality within. Indeed, persons are frequently constructed as the plural and composite site of the relationships that produce them.'[42] In the sewer we find a social manifestation of the plural and composite site of relations, made up of not only the biomass of persons, divided and 'disseminated in a "biological matter" related to, but not contained in, this individuality', or the 'traces about our lifestyles that feed huge and valuable databases' that together make up digital profiles, but also the material and immaterial expressions of our ongoing relationships.[43]

This site of relations is where, as described by Rosi Braidotti, a 'missing and virtual' people can be 'actualized and assembled'.[44] This is not the people in opposition to the multitude, created as a manageable monoubject of the state. Rather, it is 'the result of a praxis, a collective engagement to produce different assemblages'.[45] In the sewer we find that although 'we are not one and the same ... we can interact together'.[46] And in encountering the sewer's disparate traces of forms of living, from data to bodily waste, we might be able to view life and living as 'on-going flows and transformations of forces'.[47]

To better approach the fluid dynamics of the crowded multitude streaming through the sewer,[48] we might turn to the notion of *flow*.

Vibrant Flows: Circulating the Social

Viewing shit as data—and data next to shit—allows for a consideration of the vital materiality and movement of both digital data and physical excrement. Barbara Orland conceptualizes the history of knowledge of material, writing that '*flow*, or current, describes the directed kinetic movement of either a fluid continuum of a substance or a multitude of similar singularities'.[49] Within the sewer, the fluid continuum of excretal sludge and the multitude of digital dividuals flow together.[50] This course of movement is the terrain of biopolitics that Eugene Thacker describes in which a decomposing, disintegrated, diseased body politic is addressed by forms of governance that regulate 'networks, flows, and circulations'.[51]

Here we turn to Gabriel Tarde's concept of microsociology in which 'the social ... is a circulating fluid',[52] or the movement of flows of 'belief or desire'.[53] Tarde looks at diverse, small social interactions as the basis for analysing the social, rather than generalizing about collective social wholes, institutions or processes.[54] For Tarde, the 'distinction between the social and the individual loses all meaning since flows are neither attributable to individuals nor overcodable by collective signifiers'.[55] These flows are 'created, exhausted, or transformed, added to one another, subtracted, or combined'.[56] In Tarde's microsociology, a social unit can be understood as an 'ensemble, compound, or configuration of previously disperse flows of desires and beliefs'.[57] These compositions are subject to change, increasing or decreasing depending on what is added to or subtracted from the ongoing current.[58] Yet while the social and individual are not the primary figures in Tarde's microsociology, they can still be 'understood as open ensembles of immanent, contingent, and partial relationships of beliefs and desires in continuous change'.[59] It is such an open assemblage of immanence, contingency and partiality that we find in the swirling multitude of the sewer, and in its continuous, changing movement.

If prior practices of biopolitics have been cached in the realm of valuation, classification, quantification and regulation—practices related to signification and the semiotic—then perhaps the notion of shit as data and the vital materiality of data can shift these practices into a semantic realm, into meanings that shift and move, just as our data and excrement do. The notion of vibrant data attempts to resist the semiotic, financialized arrest of data by grounding information *through* materiality and its social flows. N. Kathleen Hayle discusses the disembodiment of information during the Macy Conferences on Cybernetics, when Norbert Wiener and Claude Shannon established a stable conception of information that was divorced from meaning and instead focused on the transmission of messages, excluding consideration of their context or the observer. For Shannon, 'defining information as a probability function was a strategic choice that enabled him to bracket semantics'.[60] What would it mean to return semantics to information? How might we allow semantics to enter into the circulation of data and shit that flush through the sewers, so that the meeting of sewage and language does not merely reproduce Laporte's recollection of the institution of centralized state power?

The semantic, according to linguist Émile Benveniste, opens up a notion of language that is a site of transformations, language as something that moves, rather than merely a linguistic system that rigidly upholds signs.[61] A reconsideration of the semantic aspect of information revisits the establishment of cybernetics and the construction of information as disembodied and dematerialized to retrace an alternate route in which information is necessarily dependent on and subject to structural, social and material conditions. The information in our data and biomass is necessarily relational, as are our biogenetics: 'Like the dividual self in an anthropological sense, genomic data gain their meaning and utility in reference to the wider genomic cohort.'[62] The sewer as an information infrastructure allows for a relational and semantic approach to individual and dividual excrement and data. For in studying sewage, it is impossible to identify individual sources. Instead, that information must be considered in the context of the other matter that flows with it, without being coded back to original addresses. If we take a similar approach and study collected sets of digital data rather than data attributed to identified individuals, perhaps we can view data in light of its relations, as sets of changing and growing social flows.[63] In this sense, data—and its meanings—are not objectified or reified, but rather, they remain in motion, as sites for transformations.

A semantic approach to the flow of information—both digital and excretal—does not instigate the creation, maintenance and subjugation of sets of individualized subjectivities, nor does it actuate the overcoded collective subjectivities that can become tools of market research or optimized product development. Rather, this is a social subjectivity that is contingent. It produces flows of information that necessarily depend on senders, observers and environs—and these not merely as positions of value. It reconfigures information as 'compositions of the multiple collective flows' of the microsocial.[64] The excess traces of our digital and bodily activities, data and excrement manifest this informational flow that is 'the social tissue [that] always both composes and overflows the social organs'.[65]

In allowing our digital and material biosocial substances to overflow, we might arrive at a notion of grotesque data by way of Mikhail Bahktin's analysis of Rabelais's writing and world. In Rabelais's writing, 'the body and bodily life have here a cosmic and at the same time an all-people's character'.[66] The body is not individualized, and the 'material bodily principle is contained not in the biological individual … but in the people, a people who are continually growing and renewed'.[67] This, writes Bakhtin, is why 'all that is bodily becomes grandiose, exaggerated, immeasurable', why the overflowing, overgrowing body becomes grotesque.[68] The sewer circulates the social through the continually changing flow of bodily excrement and digital waste. It is the site for the circulation of embodied information and the materialization of data as a social substance. Reading data through the vital contents of the sewer might allow the multitude to overflow both individualization and mass collectivities, to instead circulate through multiple meanings and relational compositions. These social flows might enable the creation of alternate biopolitics, of a biopolitics that escapes individual capture and collective overcoding, or subjective individualization and objective totalization.

Grotesque social overflows of the body are sites of becoming, and sites of the potency of life. The sewer is the space that hosts this immense potentiality.

Notes

1 Giorgio Agamben, *Homo Sacer*, trans. Daniel Heller-Roazen (Stanford: Stanford University Press, 1998), 5.

2 For example, Eric Hayot discusses the conflation of 'information' with 'communication' by Claude Shannon and Warren Weaver in *The Mathematical Theory of Communication* as a paradigm shift in the theorization of information. In modern history, information has come to mean 'that which has no fixed form, but can be passed on from one person to another, or one medium to another, without either being significantly altered in itself, or altering that which it touches'. Eric Hayot, introduction to: Eric Hayot, Anatoly Detwyler and Lea Pao (eds.), *Information: A Reader* (New York: Columbia University Press, 2022), 6–7.

3 Or, in line with Jane Bennett's analysis, the vital materiality of things and substances and their capacity as forces or agents. Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC: Duke University Press, 2010), 113–119.

4 Georges Bataille, 'Architecture', in: Neil Leach (ed.), *Rethinking Architecture* (London: Routledge, 1997), 19–20.

5 See: Julia Kristeva and Leon S. Roudiez, *Powers of Horror: An Essay on Abjection* (New York: Columbia University Press, 1982). Kristeva elaborates on the abject as something other than the self that is, for instance, unclean or unhealthy, that which 'disturbs identity, system, order. What does not respect borders, positions, rules. The in-between, the ambiguous, the composite.' Within this plane of analysis, 'excrement and its equivalents (decay, infection, disease, corpse, etc.) stand for the danger to identity that comes from without.' Ibid., 4, 71.

6 See, for instance: Sabrina Chou, 'Live Tenders: An Incomplete Theory of Social Digestion', *Thresholds* 48 (2020), 176–185, for a possible notion of the political implications of collective digestion.

7 Agamben, *Homo Sacer*, op. cit. (note 1), 9.

8 Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Brian Massumi (Minneapolis: University of Minnesota Press, 1987), 219; see also: Gabriel Tarde, *Monadology and Sociology,* ed. and trans. Theo Lorenc (Melbourne: re.press, 2012).

9 Dominique Laporte, *History of Shit*, trans. Nadia Benabid and Rodolphe el-Khoury (Cambridge, MA: MIT Press, 2000), 2–9.

10 Hannah Arendt describes speech and action as what allows humans to appear to one another, to relate to one another, and as what constitutes the space of the *polis*, rather than any physical location. Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958), 174–88, 196–99.

11 Agamben, *Homo Sacer*, op. cit. (note 1), 9.

12 Tomáš Mackul'ak et al., 'Wastewater-Based Epidemiology as an Early Warning System of the Spreading of SARS-CoV-2 and Its Mutations in the Population', *International Journal of Environmental Research and Public Health* 18/11 (2021), 5629.

13 'Coronavirus Monitoring in Sewage Research', Rijksinstituut voor Volksgezondheid en Milieu (Dutch National Institute for Public Health and the Environment), https://www.rivm.nl/en/covid-19/sewage, last modified 12 September 2022.

14 'National Wastewater Surveillance System', Center for Disease Control and Prevention, https://www.cdc.gov/healthywater/surveillance/wastewater-surveillance/wastewater-surveillance.html, last modified 21 March 2022.

15 'Wastewater Testing Coverage Data for the Environmental Monitoring for Health Protection (EMHP) Programme', UK Health Security Agency, https://www.gov.uk/government/publications/wastewater-testing-coverage-data-for-19-may-2021-emhp-programme/wastewater-testing-coverage-data-for-the-environmental-monitoring-for-health-protection-emhp-programme, last modified 10 June 2021.

16 Mackul'ak et al., 'Wastewater-Based Epidemiology', op. cit. (note12), 5629; Kevin V. Thomas et al., 'Comparing Illicit Drug Use in 19 European Cities Through Sewage Analysis', *Science of the Total Environment* 432 (2012), 432–439; Jing Sun et al., 'Microplastics in Wastewater Treatment Plants: Detection, Occurrence and Removal', *Water Research* 152 (2019), 21–37.

17 Michael Hensel et al., 'Towards an Architectural History of Performance', *Architectural Design* 82/3 (2012), 26–37; Elisabeth Beazley, 'The Pigeon Towers of Isfahan', *Iran* 4 (1995), 105–109.

18 Chelsea Wald, 'The New Economy of Excrement', *Nature* 549 (2017), 146–148.

19 Bennett, *Vibrant Matter*, op. cit. (note 3), 113–119; Michelle Murphy, 'Against Population, Towards Alterlife', in: Adele E. Clarke and Donna Haraway (eds.), *Making Kin Not Population* (Chicago: Prickly Paradigm Press, 2018), 115. For a discussion of the multiplicity of bodies in relation to excrement and microbiota, see also: Anna Wolodzko, 'Bodies Within Affect' (PhD dissertation, University of Leiden, 2018), 145, 162–165.

20 Josbert J. Keller et al., 'A Standardised Model for Stool Banking for Faecal Microbiota Transplantation: A Consensus Report from a Multidisciplinary UEG Working Group', *United European Gastroenterology Journal* 9 (2021), 229–247.

21 See: Pieter de Groot, 'Fecal Microbiota Transplantation in Metabolic Syndrome: History, Present and Future', *Gut Microbes* 8/3 (2017), 253–267; 王国华, '最好的藥' ['The best medicine'], 視野 [*Horizons*] 13 (2014), 21.

22 Michel Serres, *Rome: The First Book of Foundations,* trans. Randolph Burks (London: Bloomsbury, 2015), 201.

23 Recent studies have framed the digital crowd as a 'form of contemporary collective life for practicing symbolic politics' that also extend 'the crowd's affective and cognitive attributes, well beyond its duration of physical gathering and actions'. Hazem Ziada, 'The Digital Crowd', *Architecture and Culture* 8/3–4 (2020), 653–666.

24 Paolo Virno, *A Grammar of the Multitude: For an Analysis of Contemporary Forms of Life*, trans. Isabella Bertoletti, James Cascaito and Andrea Casson (Los Angeles, Semiotexte, 2004), 21–22.
25 Ibid., 21–22.
26 Erica Rowan, 'Bioarchaeological Preservation and Non-elite Diet in the Bay of Naples: An Analysis of the Food Remains from the Cardo V Sewer at the Roman Site of Herculaneum', *Environmental Archaeology: The Journal of Human Palaeoecology* 22/3 (2017), 318–336.
27 Shannon Mattern, 'Deep Time of Media Infrastructure', in: Lisa Park and Nicole Starosielski (eds.), *Signal Traffic: Critical Studies of Media Infrastructures* (Chicago: University of Illinois Press, 2015), 95–112.
28 Nicole Starosielski, *The Undersea Network* (Durham, NC: Duke University Press, 2015), 4.
29 See: http://www.fiberatlantic.com/submarinecablemap/ for a map of undersea cables.
30 Stefan Stanko and Ivana Mahrikova, 'Implementation of Fibre Optic Cables in Sewage System', in: Petr Hlavinek et al. (eds.), *Integrated Urban Water Resources Management* (Dordrecht: Springer, 2016), 171–180.
31 Sanjiv Gokhale, 'Deployment of Fibre Optic Networks through Underground Sewers in North America', *Journal Of Transportation Engineering* 132/8 (2006), 672–682.
32 Ibid., 673–677.
33 Ibid., 672.
34 Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2016), 37–71, 41.
35 Tarde, *Monadology and Sociology*, op. cit. (note 8), 16–18.
36 Shoshanna Zuboff, *The Age of Surveillance Capitalism* (New York: PublicAffairs, 2019), 37–51.
37 Fernanda Bruno and Pablo Manolo Rodriguez, 'The Dividual: Digital Practices and Biotechnologies', *Theory, Culture and Society* 39/3 (2021), 39–40.
38 Giorgo Agamben, *The Use of Bodies*, trans. Adam Kotsko (Redwood City, CA: Stanford University Press, 2016), 225–226.
39 Ibid., 225.
40 Ibid., 225–226.
41 Bruno and Rodriguez, 'The Dividual', op. cit. (note 37), 40.
42 Marilyn Strathern, *The Gender of the Gift: Problems with Women and Problems with Society in Melanesia* (Berkeley: University of California Press, 1990), 13.
43 Bruno and Rodriguez, 'The Dividual', op. cit. (note 37), 39–40.
44 Rosi Braidotti, *Posthuman Knowledge* (Cambridge: Polity Press, 2019), 101. Judith Butler writes about the potential in acts of assembly that are enactments of the gathering of bodies that allow for difference rather than mass homogeneity: '*... the assembly is already speaking before it utters any words* ... To act in concert does not mean to act in conformity; it may be that people are moving or speaking in several different directions at once, even at cross purposes.' Judith Butler, *Notes Toward a Performative Theory of Assembly* (Cambridge, MA: Harvard University Press, 2015), 156–157.
45 Ibid., 101.
46 Ibid., 101.
47 Ibid., 100. Here Braidotti is discussing Deleuze's assertion that life is not one system.
48 Indeed, the movement of crowds is studied using the physics of fluid dynamics. See, for example: Muhammad Umer Farooq et al., 'Motion Estimation of High Density Crowd Using Fluid Dynamics', *The Imaging Science Journal* 68/3 (2020), 141–155.
49 Barbara Orland. 'Matter in Flux: How to Study the Dynamic States of the Material World', in: Jennifer Teets (ed.), *Electric Brine* (Berlin: Archive Books, 2021), 43–63.
50 See Manuel Castells's discussion of the network as the 'space of flows'. Manuel Castells, *The Rise of the Network Society* (Oxford: Blackwell Publishers, 2000), 442. For the engineering of sewage flows, see: Thomas Barlow, *Hydraulics: Gauging of Sewage Flows, etc.: A Handbook of Rules and Tables for Engineers and Managers of Sewage Disposal Works* (London: Lockwood, 1926); Franz Tscheikner-Gratl et al., 'Sewer Asset Management: State of the Art and Research Needs', *Urban Water Journal* 16/9 (2019), 662–675.
51 Eugene Thacker, 'Necrologies; or, the Death of the Body Politic', in: Patricia Ticineto Clough and Craig Willse (eds.), *Beyond Biopolitics: Essays on the Governance of Life and Death* (Durham, NC: Duke University Press, 2011), 152.
52 Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2007), 13.
53 Deleuze and Guattari, *A Thousand Plateaus*, op. cit. (note 8), 219.
54 Sergio Tonkonoff, 'A New Social Physic: The Sociology of Gabriel Tarde and Its Legacy', *Current Sociology* 61/3 (2013), 267–282.
55 Deleuze and Guattari, *A Thousand Plateaus*, op. cit. (note 8), 219.
56 Ibid., 219.
57 Tonkonoff, 'A New Social Physic', op. cit. (note 54), 275.
58 Ibid., 275.
59 Ibid., 276.
60 N. Katherine Hayles, *How We Became Post-Human* (Chicago: The University of Chicago Press, 1999), 50–55.
61 Émile Benveniste, *Last Lectures: College de France 1968 and 1969*, ed. Jean-Claude Coquet and Irene Fenoglio, trans. John E. Joseph (Edinburgh: Edinburgh University Press, 2019), 125–127.
62 Ian McGonigle, 'Genomic Data and the Dividual Self', *Genetics Research* 101/12 (2019), 2.
63 For instance, Mélanie Dulong de Rosnay and Felix Stalder have written about the digital commons, wherein resources of 'data, information, culture, and knowledge ... are created and/or maintained online'. They posit the digital commons as 'a political institution and as a way to expand democratic participation beyond the framework of representative democracy, through self-governance, 'participation, flexibility, and collaboration throughout society'. Significantly, the notion of a data commons could provide resistance against the 'increasing centralisation and commodification of data in the hands of a small number of companies', to instead govern data as a commons. Yet, as De Rosnay and Stalder write, this commons is yet to be constituted, as it still lacks a 'conceptual and legal framework', and the differentiation between open data and members-based commons data. Mélanie Dulong de Rosnay and Felix Stalder, 'Digital Commons', *Internet Policy Review* 9/4 (2020), 2, 15, 16.
64 Tonkonoff, 'A New Social Physic', op. cit. (note 54), 279.
65 Ibid., 275.
66 Mikhail Bakhtin, *Rabelais and His World*, trans. Hélène Iswolsky (Bloomington: Indiana University Press, 1984), 19.
67 Ibid., 19.
68 Ibid., 19.

MACHINES

MACHINES IN LANDSCAPE/TERRITORIAL INSTRUMENTS

On the Sociotechnical Production of Planetary Platforms

Ali Fard

Elusive by Design

In 2009, Kevin Kelly, one of the cofounders of WELL and the longtime executive editor of *Wired* magazine, asked his followers on the web to draw their interpretation of the Internet as a map.[1] Since then, the project has garnered more than 270 submissions on Kelly's Flickr page.[2] A cross-sectional reading of all submissions reveals the overwhelming abstracted conceptions of the Internet that dominate most of these maps. Projects like this point to the lack of clarity and articulation that prevails in popular imaginaries of large technical systems, and the duality at the core of how planetary technology platforms are produced. On the one hand, metaphors and marketing generate a sociotechnical imaginary of data platforms that intensifies myths of immateriality, inherent sustainability and technologically mediated societal progress. This sociotechnical imaginary actively undermines the material geographies, power relations and labour conditions that are at the core of platforms and their operations. On the other hand, the production of data and its mobility necessitate the spatial (re)production of operational landscapes of extraction, storage and processing, as well as infrastructural geographies of circulation that accommodate the continual expansion of platforms and the enclosure of resources at the core of twenty-first-century data capitalism. These infrastructural extensions in turn create an uneven geography of data that is essential to the production of platforms, but that has largely been black-boxed behind imagery and metaphor and has escaped critical attention in discussions of urbanization and technology.

To fully capture the intricacies of how planetary platforms are produced, we need to come to terms with this duality. Given the interwoven relationship between representation and materiality in the production of platforms, the framework of sociotechnical imaginaries presents a productive starting point to examine the coproduction of sociocultural practices and technological development. Emerging discourses in urban studies, such as discussions around planetary urbanization, that reengage with urbanization through a relational reading of both its concentrated and extended moments, also provide a helpful conceptual basis for examining the spatial impact and imprints of platforms beyond the city. Ultimately, a material rereading of the infrastructural landscapes of data, complemented by a critical understanding of their political imaginary, begins to complicate the smooth and frictionless reading of the operations of tech platforms and how they are produced.

Capturing the Cloud

The notion of the 'cloud', which has been widely popularized since its emergence in the early 2000s, is a good example of how metaphors are operationalized in the sociotechnical imaginaries of data infrastructure. Clouds of the water vapor kind are naturally formless. They are in a state of constant flux, changing shape and direction based on temperature fluctuations and wind dynamics. Hence, to represent a cloud is to abstract its amorphous nature, to freeze its continually changing form in time and space, an abstraction that is necessary for its representation. The same logic of abstraction is at play in reference to the cloud of the digital kind. Emerging from the technical network drawings of the 1970s, the metaphor of the 'cloud' renders the complex ever-expanding global network of digital infrastructures as 'a single, virtual, object'.[3] A representation that is increasingly important to the marketing of the services and products that run on its critical infrastructure.

An important component of this abstraction is virtualization, which generates an analogue of computing resources with the aim of efficiently sharing them among multiple users at any given time. Evolving from the time-sharing of mainframe computers in the 1960s, virtualization enables the cloud 'to distribute, meter, and charge for these computing resources in highly granular and flexible ways'.[4] But the concept can also more generally be understood as 'a technique for turning real things into logical objects', hence abstracting their relationship to a material base.[5] The reconfigurative power of virtualization persists through the representation of the cloud. The very term 'the cloud' denotes a singularity that sweeps under the rug the multiplicities of network forms and the dynamically competitive world of cloud computing, which boasts a large variety of actors, services and user types. A single object is finite; it can be secured; it can be controlled. The structure of an object is clear; it can be understood and communicated. An object can be mastered and naturalized, hence becoming a tool of advancement. An object can be fetishized, hence marketed and sold. Not all of these things could be done if the cloud was represented as a complex, infinitely expandable collection of networks of varied devices, protocols and connections.

Virtualization, as both a technical process and a representational practice, has therefore enabled the imagination of a parallel, more data-driven, spatial condition to that of 'real' space. A Google image search for 'cloud computing' returns an array of similarly shaped, abstract and cartoonish depictions of clouds. The results reflect the dominance of the virtual icon in all aspects of technological representation, from marketing images to network diagrams. It also portrays a general ambivalence to what the cloud actually is or what it does. The icons and the images that stand in for the cloud instead accommodate the virtualization of the material basis upon which it is constructed: while they manage to capture the ease, the security and the familiarity of the operations of the cloud, they concurrently blur the actual effort, vulnerability, space and infrastructure of its delivery, as well as the extended material geography and the environmental degradation that it entails.

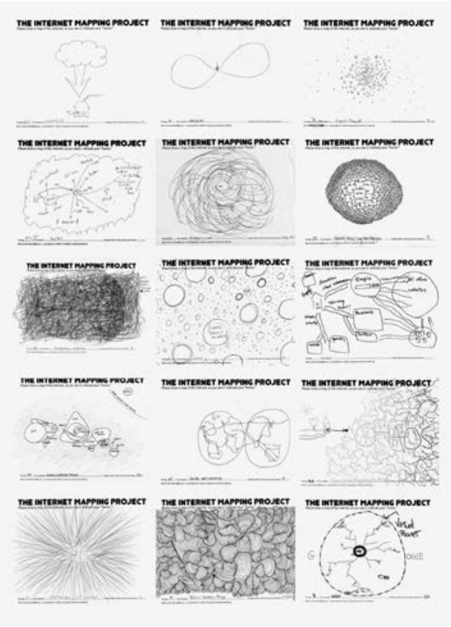

Fig. 1 A representative sample of submissions to Kelly's Internet Mapping Project. Images courtesy of Kevin Kelly on Flickr

In the absence of clear technical or easily digestible representations, the info-industrial complex has always relied on metaphors for marketing and generating a sociotechnical imaginary of its projects.[6] The sociotechnical 'co-production' of imaginaries is a particularly useful concept to the critical analysis of technology platforms.[7] Jasanoff elaborates on sociotechnical imaginaries as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology'.[8] And while sociotechnical imaginaries are often promoted through the state, as Sadowski and Bendor have shown in the context of 'smart' urbanism, the particularities of contemporary data technologies and their development and marketing situate corporations as the main actors in shaping and extending sociotechnical imaginaries of platforms. In this sense, 'large technology vendors set the tone, enroll other actors, and weave the narratives' that allow the tech sector's strategists, now turned urbanists, to strongly position themselves and their platforms as harbingers of a new paradigm of urbanism.[9]

Urbanizing Platforms

In the emerging sociotechnical imaginary of tech platforms, the city is treated as a frontier of data-driven projects that attempt to deal with a variety of issues facing contemporary urbanization. Abstraction and metaphors abound within these imaginaries, which re-present the spatial projects of tech as part of a singular, clean, objective, efficient and transformative platform logic. This further imbues the urban operations of data platforms with techno-utopian ideologies of progress that attempt to justify the colonization of everyday life through technology as a necessary consequence of responding to the socioenvironmental challenges of urbanization.[10] Within these abstractions it is easy to forget that every click, every sensor, every screen and every AI platform in the urban model propagated by tech is ultimately linked up to clouds of data that

Fig. 2 An image search of 'cloud computing' returns a slew of abstracted cloud icons

depend on infrastructural landscapes and material geographies that stretch well beyond the city. Yet, the urban projects of tech platforms are portrayed as highly defined entities with clear boundaries that operate on the city as a wholly knowable, manageable and ultimately controllable archipelago in a sea of an undefined periphery.

In a process evocative of the undergrounding of urban systems at the turn of the twentieth century, the infrastructural landscapes of data production and technology development form the blurry background to the overhyped operations of platforms in cities. The disappearance of the urban monuments of modernism from the cityscape, in response to the failure of the emancipatory project of modernity and the unfulfilled promise of delivering a better society, prompted the construction of new sociotechnical imaginaries built around notions of lightness, sustainability, convenience and effortlessness.[11] By the 1990s a new techno-utopian ideology was in full effect; this time driven by rapid advancements in digital information and communication technologies. As Graham elaborates, the mystique that was attached to electronic (and later digital) communication technologies between the 1960s and the 1990s was such that 'ICT-mediated shifts away from place and city-based lives were often uncritically assumed to automatically also involve shifts towards more democratic, egalitarian, decentralized and ecologically sensitive societies'.[12]

While these decentralized visions still animate the sociotechnical imaginaries of platforms, rapid urbanization and the densification of global population centres—with their massive cache of potential data—has meant the re-ascendance of the city as the site, and the target, of the urban operations of platforms. The emerging literature on platform urbanism is indicative of this city-centric, administratively bounded and anthropocentric focus.[13] Similarly, discussions of 'smart cities' are bogged down by a 'methodological cityism' that has limited a broader and more complex understanding of how urban technology regimes are constructed atop globally extended material geographies with inherent political, social and spatial intricacies.[14] And while the patina of immateriality is slowly wearing off, the hidden forms of tech platforms and the obscurity of the means of data production, mediated through abstractions and marketing, still privilege the city over the operational landscapes of data, where the primary production of platforms takes place. Even when the operational spaces of platforms are highlighted, their representation is folded into a narrative of technological progress and peaceful cohabitation of technology and environment, which attempt to iron out the social, environmental and political tensions that are at the core of the territorial project of planetary platforms.

Machines in Landscape and Territorial Instruments

In 2012, Google released a series of photographs of its data centres, which up to that point had existed in a shroud of mystery. In addition to closeup shots of flickering lights and carefully lit rows of server stacks, the facilities were shown surrounded by mountains, rivers and wildlife. This idyllic imagery was very different from the screen-side representation of Google or the images of its campus in California that had dominated the representations of the company up to that point. Yet the juxtaposition of the massive machinery of data centres, and their backup generators and clouds of steam, with the surrounding sleepy countryside was not easy to digest. The sublime imagery simultaneously recalled the disruptive quality of technology in Leo Marx's *The Machine in the Garden*, and Hans Hollein's fantastical collages of technical objects in landscapes.[15] Whereas Marx's writing examined the relationship between culture and technology in nineteenth- and twentieth-century American literature, Hollein's collages belonged to the radical architecture movement of the 1960s, which included Archigram, Superstudio and Archizoom. The movement that emerged partly in response to post-Second World War modernist architecture, attempted to re-evaluate the relationship between society and technological changes brought on by mass communication and information technologies, particularly the telephone and the computer.[16]

Hollein's collages from this period, which included surreal juxtapositions of rural landscapes with aircraft carriers or technical objects like sparkplugs and theodolites, attempted to create a more appropriate (architectural) imagery of its time. This was not the first and would not be the last time that architects would mobilize technical objects of their time as foundational drivers of a 'new' architecture. But while Hollein's collages were meant to be provocative by playing up the uncomfortable juxtaposition of technology and landscape, Google's images attempt to strike a harmonious tone between data infrastructure and nature. In this sense, 'where the internet lives' is presented matter-of-factly as a part of—and perhaps positively contributing to—the natural environment.

But the technological sublime of these images goes well beyond pacifying the environmental impact of platforms. In the context of the competitive dynamics between major tech platforms, representing infrastructure and technical apparatus enables a staking of ground within corporate territory as platforms extend their territorial claim and operations. As Holt and Vonderau have argued, the infrastructural politics that is played out through this imagery is 'about the hypervisibility created around some of an infrastructure's component parts, all while most of the relations it engenders and the rationality embodied in its overall system sink deeply in obscurity'.[17] The obscurity of their means of production

Fig. 3 Google's Council Bluffs data centre in Iowa during wildflower bloom and visited by deer. Images courtesy of Google.

and the power relations enacted through them enables platforms to produce an abstraction that is essential for their representation and marketing, and hence their territorial expansion.

This points to an important contradiction between abstraction, metaphors and the material operations of platforms. While technology platforms have introduced new dynamism and hypermobility to information, capital and social interactions, this fluidity is continually materialized in the very physical infrastructure of connectivity that enables the operations of platforms. This 'spatial fixity' is at the core of capitalism's tendency towards geographic and territorial expansion.[18] Central to this expansion is the construction of massive infrastructural networks and capital investment into pipes, cables, roads, ports and railways that underlie and connect concentrated moments of agglomeration, a process that 'grounds' these infrastructural networks in the very space and time they are trying to overcome. Consequently, the 'annihilation of space through time' (that is, the creation of frictionless, efficient conduits of capitalist production and circulation) necessitates investments into physical infrastructures of transportation and communication.

As mediators between the contemporary information society and its data, tech platforms are entangled in a similar process. The production and circulation of data entails the spatial (re)production of operational landscapes of extraction, storage and processing, as well as infrastructural geographies of circulation that are necessary for the continual expansion of platforms. The processes at the core of platform capitalism demand continual territorial expansion and competitive enclosure of increasingly sparse resources.[19] Google, for example, has spent more than $30 billion on its global cloud infrastructure.[20] Amazon has spent $35 billion on data centres in Northern Virginia alone.[21] Microsoft, Amazon, Google and Facebook have invested so heavily in undersea fibreoptic lines that their private networks' bandwidth capacity now completely overshadows the backbone of the Internet.[22] All these developments point to the importance of infrastructural landscapes and material support systems to the expansionist operations of platforms. It is these operational geographies that platforms leverage to exert their considerable power in cities. Recent discussions in urban studies have productively positioned concentrated moments of urbanization in cities in direct relationship to material and infrastructural extensions beyond population centres.[23] Elaborating on these extended 'operational landscapes' of platforms would allow for a more nuanced reading of the spaces, scales and more-than-human geographies that are not captured in the current city-centric discussions of platform urbanism and the surficial reading of the 'countryside' as a categorically separate part of contemporary urbanization.[24]

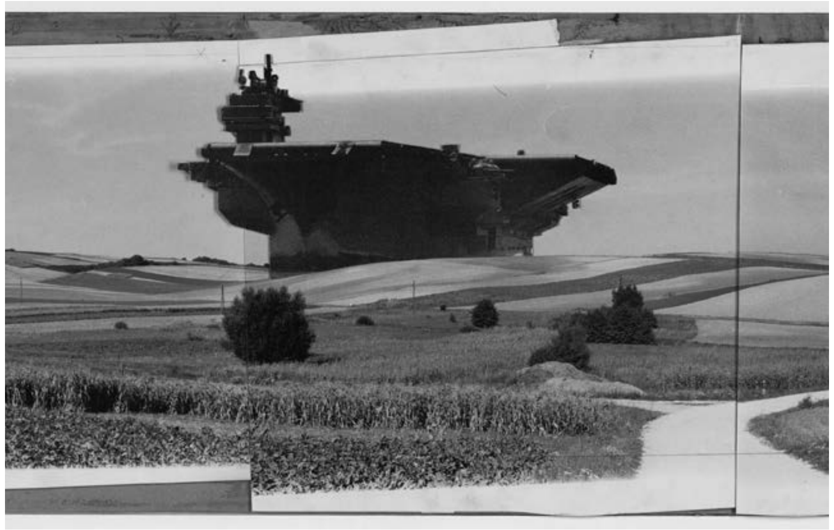

Fig. 4 Hans Hollein's Aircraft Carrier City in Landscape (1964). © Private archive Hollein; digital Image © The Museum of Modern Art/Licensed by SCALA / Art Resource, NY

Excavating the Infrastructural Palimpsest of Platforms

The grounding of the cloud entails a spatial logic based on a geopolitical cocktail of economic, political and environmental conditions.[25] In locating their nodes, platforms have followed in the footprints of previous rounds of capitalist spatial production. Data centres are often located on top of the ghosts of the manufacturing economy or within the spatial vestiges of the military industrial complex of the Cold War.[26] The infrastructural and security surplus built into these leftover spaces means significant savings for data-centre companies. This problematizes the idealized spatial imaginary of contemporary technology platforms. Whereas lightness and revolutionary spatial dynamism tend to characterize data technology and its spatial footprints, in reality tech platforms are highly dependent on previous rounds of infrastructural development and the established processes of enclosure and privatization at the core of neoliberal urbanization.

The conceptual framework of palimpsest can help articulate the sectional interrelationships and territorial interdependencies inherent to the sociotechnical production of planetary platforms. While the metaphor of the palimpsest has been used in architecture and urban design to describe the temporal layering and stratification of spatial interventions, in the discussion of platforms it can help explode the otherwise flat image of data technology. As Sébastien Marot has explained in relationship to contemporary landscapes, 'the palimpsest contributes a much needed dimension of materiality, givenness, gravity, inertia, and care' to the 'hyperlandscapes' of the contemporary urban condition.[27] A palimpsestuous reading of the production of planetary platforms integrates the otherwise hidden contribution of more-than-human geographies, environments and species, and reintroduces weight, depth and intricacy to the spatial discussion of technology platforms. The palimpsest as a conceptual framework for the analysis of the grounded spatial relationships of platforms is particularly helpful in the context of recent reconceptualization of planetary-scale computing, especially in the work of Benjamin Bratton and the notion of the Stack.[28] Whereas the Stack presents the planetary computing system as a series of interrelated but otherwise discrete layers, the palimpsest frames it as an inherently complex and intertwined condition. Through the palimpsest it is difficult to separate the layers from one another as they form a new whole. This ultimately strengthens the relational reading of spatial interdependencies at the core of the sociotechnical production of platforms.

Furnishing the Cloud

To fully articulate the potential of this palimpsestuous reading we can go back to Google. The company's Lenoir data centre was among the first series of large purpose-built data centres that Google constructed in the early 2000s. Lenoir is a small industrial city of around 18,000 people and the seat of Caldwell County in western North Carolina. Lenoir's location in the foothills of the Blue Ridge Mountains ensures relatively cooler temperatures compared with areas in the eastern part of the state, which is very beneficial for the maintenance of the many servers in Google facilities. The area is not disaster prone, and the proximity of Lenoir to Charlotte, NC and other major East Coast population centres also makes the city and the region an attractive destination for data centres. The city's previous industrial history was also critical in Google's decision to locate there. By the early 2000s the city's many furniture factories were facing massive competition from their Asian counterparts. Between 1992 and 2012, furniture manufacturing in North Carolina declined 56 per cent and employment in manufacturing has also steadily fallen.[29] Between 2004 and 2007, Lenoir saw the closure of seven furniture factories and the loss of 2,100 jobs.[30] The closing of factories meant that the excess power capacity that had been built for manufacturing over the past 50 years became available. The local electricity utility, Duke Energy, was willing to offer this excess capacity at very low rates for industrial use.[31]

By late 2005 when Google came calling, Lenoir's city officials, led by the Caldwell County Economic Development Commission and supported by the state of North Carolina, were ready to offer the company a massive incentive package to locate its data centre in the city. Nanette Byrnes, writing for *BusinessWeek* in 2007, valued the incentives offered by the city, the county and the state at $211.7 million for Google's initial $600 million facility.[32] As part of the incentive package the state legislature enacted a 'Google-driven' bill that allowed for data centre-specific sales and use tax exemptions. The state legislature's efforts were pushed along by Google's threats to back out of Lenoir if the bill was not enacted quickly.[33] The legislation was passed in a month. The bill effectively exempts Google from paying sales taxes for the massive amounts of the electricity that its data centres use. Servers, software and other equipment (comprising 'HVAC and mechanical systems, including chillers, cooling towers, air handlers, pumps and other capital equipment used for these purposes') would also be exempt.[34] For its part, the city of Lenoir offered a 100 per cent discount on local property taxes and 80 per cent off real estate taxes for 30 years. A substantial offer given Google's initial purchase of 216 acres of land. Since its initial 2007 project in Lenoir, Google has expanded its facilities and has doubled its investment to $1.2 billion.[35] In 2008 the company purchased an additional 60 acres, bringing its total to 276 acres of land.[36] This also means that the value of the incentive package offered by the city and the state has in turn increased well beyond the initial $211.7 million.

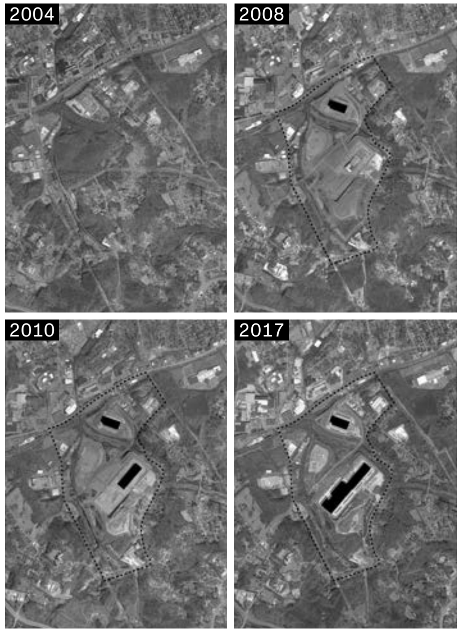

Fig. 5. Progressive development of Google's data campus in Lenoir, NC, 2007–2017

Beyond incentives, the heavy energy usage of data centres entangles these footprints of platforms with the geopolitics and the environmentally degradative extractive practices of energy production and transmission. Greenpeace has highlighted the heavy toll that all this increased energy consumption has on the environment. In Greenpeace's 2015 report, of the major tech companies that it analysed only two source more than 50 per cent of their electricity needs from clean energy sources. Additionally, energy from coal is still responsible for a considerable chunk of the energy used by data centres and platform companies.[37] Following the report and relying on their huge purchasing power in North Carolina, Google and Apple have successfully encouraged Duke Energy to start a renewable energy programme and to invest heavily in solar energy production in the region.[38] This is not a small shift for the United States' largest electricity utility. In 2015 only 2 per cent of the energy provided by Duke Energy was from renewable sources, while coal accounted for 32 per cent.[39] And even though the new investment presents a positive shift towards renewable energy production, it only accounts for a meagre 0.006 per cent (278 of 50,000 megawatts) of the capacity produced nationally by the company.[40] As one of the catalytic forces that brought Google and Apple to the state, Duke Energy is by North Carolina law the sole provider of power to customers. And the energy used in data centres is as clean or dirty as the

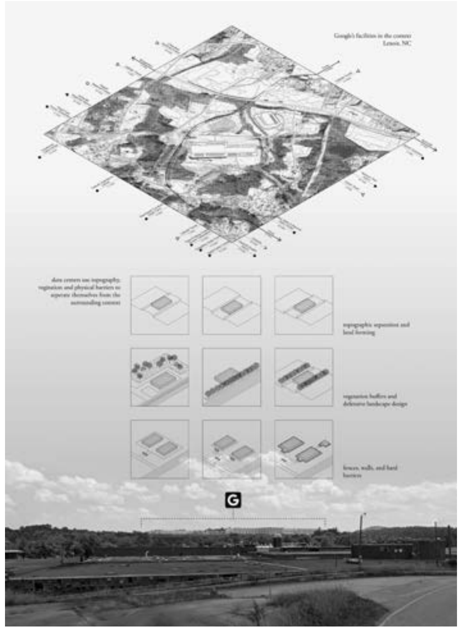

Fig. 6 Google's Lenoir facilities in context. Bottom: Google's data centres perched on top of the city in the midst of abandoned factories. Viewed from 467 Virginia Street SW. Middle: typical spatial strategies of data centres. Top: Lenoir data centres and their proximities and spatial dependencies.

local power grid that supplies it. One may question then whether the new push by Google for Duke to adopt renewable energy actually holds any merit or if it is solely cosmetic. In either case, the extractive logic of platforms makes sure that the decision ultimately comes down to economics. 'The price of renewable-power sources are far less volatile than power derived from commodities like coal, which is useful for things like long-term budgeting and cost-cutting.'[41] The decision is as much a business tactic as it may be a marketing one.

So, what is the actual value of having a data centre in your backyard? Initially the Lenoir project was touted for its economic regenerative potential for the city. Following years of decline, the city was ready to embrace a 'new economy', and to be part of the twenty-first century. As Byrnes wrote in 2007, Google was welcomed in Lenoir with open arms and was seen as 'a vital morale booster, if not a full replacement for the lost furniture factories'.[42] Although the construction of the data centres would mean more construction jobs initially, these are temporary employment opportunities. Data centres are known for their lean workforce. By 2015 Google employed 250 people in Lenoir, of which 150 were 'white-collar technical staff' who attend to the 50,000 servers of the facility. The remaining 100 employees were mostly security guards and HVAC technicians. Only about two thirds of the employees actually lived in Caldwell County.[43] Based on Google's own estimate, the company has created 340 jobs in all of North Carolina.[44] That number can hardly replace the more than 3,000 jobs that have been lost in Caldwell County since Google came to town.[45] Even spatially, a typical data centre's defensive strategies use topography, vegetation and hard barriers like fences and walls to cut it off from its immediate context while maintaining heavy dependence on regional infrastructures of energy, water and data.

Hence, the expansionist logic of platforms demands a complex set of geographic requirements and entails a series of spatial dependencies that together form the infrastructural palimpsest at the core of the sociotechnical production of planetary platforms. In Lenoir, the infrastructural surplus left over from many years of industrial development, inexpensive energy and real estate, proximity to population centres, political/economic lubrication through incentives and customized legislation, optimal climatic and environmental conditions, and, as importantly, the social and cultural conditioning of the local population through socially progressive imaginary propagating the 'transformative' role of twenty-first-century technology, all coalesce into a dense and complex sociotechnical palimpsest that cannot be easily decoded or simplified. Too often, however, narratives on platforms nullify this complexity by isolating and focusing solely on one of these factors, be it local economic generation or environmental impact. A palimpsestuous reading of these critical but latent dependencies allows for a richer, albeit a much more complex, relational understanding of the spatial imprints of planetary platforms.

Complicating Things as Method

The above episodes help to illustrate the intertwined relationship between the sociocultural representation and the material geographies of data infrastructures. While at times each subverts or obfuscates the other, both are critical components of the sociotechnical production of planetary platforms. This helps extend the argument that, as opposed to 'accidental megastructures', technology platforms are highly designed sociotechnical entities.[46] Tech platforms combine ideology, myth and marketing to construct amorphous and all-encompassing narratives that socially and culturally condition their users, while actively hiding their dependence on the infrastructural landscapes, material geographies and operational extensions that increasingly encompass the globe. As the computational logic of digital platforms begins to dominate urban life, tech corporations leverage this planetary geography to exert ever more control over the organization of urban spaces and the people whose data they depend on. However, by externalizing these operational landscapes, tech platforms essentially evade responsibility and avert attention from the grounded dynamics and the geopolitical messiness of data technology. As shown through cases like Lenoir, the scrambling for resources and territory within the expansionist logic of platforms exacerbates their negative social, political and environmental impact.

As planetary platforms like Meta, Amazon and Alphabet come under increasing scrutiny, their sociopolitical impacts need to be contextualized within the extended geography of their operations, and the real geographic and environmental toll of their infrastructures. Excavating the tension between how these platforms are represented and the palimpsestuous spatial dependencies at the base of their construction can greatly contribute to our understanding of the actual impacts these platforms have on global processes of urbanization. And while initially this may complicate the smooth and effortless image of platforms, this complexity will ultimately be productive in generating a more intricate reading of the intertwined relationship between narrative and material conditioning of the ground as tech corporations' power and influence continues to expand.

Notes

1 The Whole Earth ’Lectronic Link, or the WELL, is one of the earliest forms of a virtual community that was launched in 1985.
2 The drawings have continued to be collected on the page since March 2009. The most recent entry, at the time of writing, was in January 2019. See: Kevin Kelly, ‘Internet Mapping Project’, Flickr, 2009, https://www.flickr.com/photos/kevinkelly/sets/72157613562011932/.
3 Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2015), X.
4 Jean-François Blanchette, ‘From Digital Exceptionalism to Computational Scarcity’, in: Ali Fard and Taraneh Meshkani (eds.), *Geographies of Information (NG7)* (Cambridge, MA: Harvard University Press, 2015), 26.
5 Hu, *A Prehistory of the Cloud*, op. cit. (note 3), X.
6 Shannon Mattern, ‘A City Is Not a Computer’, in: Shannon Mattern, *A City Is Not a Computer: Other Urban Intelligences* (Princeton, NJ: Princeton University Press, 2021), 51–72.
7 Sheila Jasanoff, *States of Knowledge: The Co-Production of Science and Social Order* (New York: Routledge, 2004).
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9 Jathan Sadowski and Roy Bendor, ‘Selling Smartness: Corporate Narratives and the Smart City as a Sociotechnical Imaginary’, *Science, Technology, & Human Values* 44/3 (2019), 543.
10 Adam Greenfield, *Radical Technologies: The Design of Everyday Life* (London/New York: Verso, 2017).
11 See: Stephen Graham and Simon Marvin, *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition* (London/New York: Routledge, 2001); Maria Kaika and Erik Swyngedouw, ‘Fetishizing the Modern City: The Phantasmagoria of Urban Technological Networks’, *International Journal of Urban and Regional Research* 24/1 (2000), 120–138.
12 Stephen Graham, *The Cybercities Reader* (London/New York: Routledge, 2004), 8.
13 Peter Mörtenböck and Helge Mooshammer (eds.), *Platform Urbanism and Its Discontents* (Rotterdam: nai010, 2021); Sarah Barns, *Platform Urbanism* (Singapore: Springer Singapore, 2020).
14 Hillary Angelo and David Wachsmuth, ‘Urbanizing Urban Political Ecology: A Critique of Methodological Cityism’, *International Journal of Urban and Regional Research* 39/1 (2015), 16–27; Ali Fard, ‘Cloudy Landscapes: On the Extended Geography of Smart Urbanism’, *Telematics and Informatics* 55 (2020), 101450.
15 Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (Oxford: Oxford University Press, 1964).
16 Simon Sadler, *Archigram: Architecture without Architecture* (Cambridge, MA: MIT Press, 2005).
17 Jennifer Holt and Patrick Vonderau, ‘“Where the Internet Lives”: Data Centers as Cloud Infrastructure’, in: Lisa Parks and Nicole Starosielski (eds.), *Signal Traffic: Critical Studies of Media Infrastructures* (Chicago: University of Illinois Press, 2015), 80.
18 David Harvey, ‘Globalization and the “Spatial Fix”’, *Geographische Revue* 3/2 (2001), 23–30.
19 Nick Srnicek, *Platform Capitalism* (Cambridge: Polity Press, 2017).
20 Eric Schmidt, the Chairman of Alphabet, mentioned the $30 billion investment in Google’s infrastructural expansion at Google Cloud’s Next conference in San Francisco on 8 March 2017. See: ‘Google Cloud Next, 17—Day 1 Keynote’, YouTube video, 2:04:35, posted by ‘Google Cloud’, 8 March 2017, https://youtu.be/j_K1YoMHpbk. See also: João Marques Lima, ‘Google’s Cloud CAPEX Hits $30bn with More to Come as Giant Plans 10 New Data Centres’, *Data Economy* (March 2017), https://data-economy.com/googles-cloud-capex-hits-30bn-come-giant-plans-10-new-data-centres/.
21 Rich Miller, ‘AWS Has Spent $35 Billion on Its Northern Virginia Data Centers’, *Data Center Frontier* (2021), https://datacenterfrontier.com/aws-has-spent-35-billion-on-its-northern-virginia-data-centers/.
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THIS WAY: E

THIS WAY: EXPRESSIVE SELF-TRACKING AS CREATIVE PRACTICE

Joost Grootens

In the early 1960s, Suriname-born Dutch conceptual artist Stanley Brouwn (1935–2017) approached random pedestrians and asked them to draw directions to a particular place on a piece of paper. The resulting maps consist of sometimes clumsily drawn loops, lines, circles, arrows, crosses and street names. Subsequently, Brouwn stamped the text ‘This Way Brouwn’ on the drawings and exhibited them as his works of art.[1]

In the above description of the work of art *This Way Brouwn*, several themes emerge that I will address in this article about self-tracking as creative practice: navigation, drawing, mapmaking, expression, appropriation and the role of non-specialists. I will explore how evolving digital technologies influence how we use, measure and display our surroundings, and draw comparisons between Brouwn’s work of art and a map drawn some 60 years later by a Dutch cyclist, to analyse the technological, economic, political, sociological and theoretical dimension of fitness apps and GPS navigation. The article will focus on the material side of these technologies and the visualization practices they enable.

Self-Tracking as a Creative Practice

Self-tracking is the recording and monitoring of specific features of one’s own life. It is also called lifelogging, personal analytics, personal informatics and the quantified self.[2] These practices go back to the keeping of a diary, but have changed with the dispersion of mobile digital devices. Activity tracking or fitness tracking is a specific kind of self-tracking. Using the Global Positioning System (GPS) and other functionalities of mobile and smart devices, the position and duration of sport activities are recorded as well as the condition of the body in terms of heart rate and blood pressure. Fitness apps keep track of the recorded data and combine these to give users insight and comparison through infographics and maps.

Writing a text or drawing an image making use of satellite navigation is called GPS drawing. Individuals run, cycle, swim, drive, boat or fly a preplanned route to create a large-scale image. Using smart devices with GPS functionality, and software such as fitness apps, to capture the drawing in a GPS exchange format (GPX), the image is then visualized as a line on a map. Other names for GPS drawing are GPS art and Strava art, the latter named after the widely used fitness app and social network for athletes Strava, about which more later. Below, I will describe a specific GPS drawing and identify and untangle the various aspects of the map.

Giro d'Italia

In the spring of 2020, at the height of the first wave of the Covid-19 pandemic, René Koppert (1960) gets on his racing bike to cycle through the south of the Netherlands. The carefully planned trip is recorded on his Garmin GPS device. The resulting drawing is a map of Italy, approximately at a scale of 1:50, projected onto the landscape of the province of North Brabant. Koppert, a former professional cyclist who raced in Dutch and Italian cycling teams in the 1980s, is based in the Netherlands but has children living in Italy.[3] In the spring of 2020, the world was in the grip of the corona virus. Italy was particularly hard hit during the first months of the pandemic. National borders were closed, events were cancelled, or postponed. The Giro d'Italia, the annual three-week Italian cycling race usually held in May, was postponed to October. After having cycled the contour of Italy, Koppert sends a screenshot of his GPS drawing to his children in Italy by WhatsApp.

In addition to the closed borders that prevented him from visiting his children, and the cancelled cycling race in which he once participated, Koppert indicates that he was also inspired by the Strava Art movement to create his map of Italy.[4] According to Koppert, GPS drawing gained popularity during the corona pandemic when it was no longer possible to exercise in groups. Making a drawing through a sporting activity and sharing it online became a substitute social activity.

Koppert designs the route of Italy's contour by opening the Strava and Google Maps websites side by side on his computer, the first zoomed in on the map of the south of the Netherlands, and the latter on the map of Italy. On the map in Strava, Koppert looks for parts that correspond in form to the characteristic outline of Italy. He starts by looking for the shape of the heel of the boot of Italy, the regions of Puglia, Basilicata and Calabria, and finds it in the road pattern around the towns of Heeswijk Dinther, Veghel and Schijndel. The drawing that is thus created is sent as a GPX-file to the Garmin GPS device on his bicycle that transforms the drawing into an itinerary. While cycling, Koppert adjusts the route, removing illogical parts and avoiding traffic lights. The line that Koppert cycles is recorded in the Strava app and opened again on his computer, after which the route is further refined, optimized and brought closer to the shape of the map of Italy. This goes back and forth five or six times between designing and cycling until the map is done.

The final route, with the shape of the outline of Italy, is about 100 km long. The northern Italian border is formed by the Maas River, the Zuid-Willemsvaart forms the Adriatic coast, the surroundings of the village of Liempde pass for Sicily, the Tyrrhenian coast is formed by the road between Schijndel and Vught, while the city of 's-Hertogenbosch forms the north of Italy, from the provinces of Liguria and Emilia Romagna upwards. Koppert's map is missing Sardinia, but this will be added later by others as the map makes its way on social media after being shared on Strava by former pro cyclist Erik Dekker[5] and reported in a local newspaper.[6]

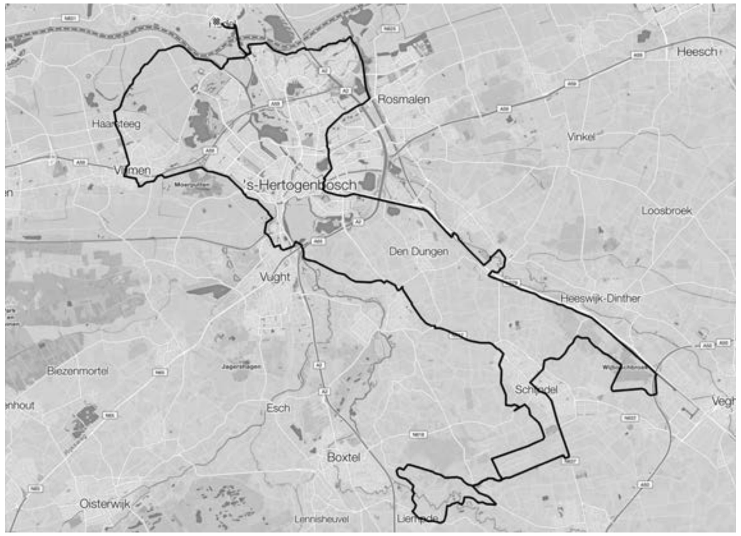

Fig. 1 René Koppert, *Giro d'Italia in The Netherlands*, Map, published on Strava, 2020.

Satellite Navigation

The technology underlying GPS drawings, such as that of René Koppert, is satellite navigation. A network of satellites and ground stations provide users with a portable receiver with accurate information about their location—anywhere, anytime and in all weather conditions. Today there are several global navigation satellite systems: GPS (United States), GLONASS (Russia), BeiDou (China) and Galileo (European Union). GPS, the oldest of the networks and the first to open its signal to all users, consists of 32 satellites circling the Earth in six orbits at an altitude of 20,200 km.[7] The satellites carry atomic clocks that are synchronized with each other and with ground stations. A GPS receiver monitors multiple satellites and calculates the exact position by measuring the time it takes to receive the different signals. A minimum of four satellites must be in 'view' of the receiver to calculate its three-dimensional location (latitude, longitude and altitude).

GPS was initially developed as a military technology, but its signal was gradually made available for civilian use as well. Releasing the signal to all sparked a commercial GPS equipment and service industry. The early GPS receivers were large, heavy and expensive. Take, for instance, the first portable consumer GPS device, the NAV 1000, manufactured by Magellan from 1989 and widely used in the first Gulf War (1990–1991). The NAV 1000 measured 22.2 × 8.9 × 6.3 cm, weighed almost 700 grams, and had a retail price of $3,000. Over time, GPS receivers became smaller, lighter, cheaper and more widely available. The Garmin Edge 530, a device similar to the one with which René Koppert made his drawing of Italy, is one tenth of the dimensions, weight and price of the NAV 1000: measuring 5.8 × 11.4 × 1.9 cm, weighing 75.8 grams and costing just under $300. Over time, GPS tracking became a feature on other devices as well, such as digital cameras, adding location coordinates to digital photos, cell phones, smartphones, where GPS tracking is a standard feature, and wearable technology such as fitness trackers and smartwatches.

While GPS technology offers individuals possibilities to compile the 'intimate particularity' of their 'personal plots', satellite navigation also provides opportunities for commercial enterprises and the state, in their quest for 'total knowledge'.[8] 'Surveillance capitalism'[9] and 'liquid surveillance'[10] are terms used to describe these monitoring practices in which the user's behavioural data is the source of new economic value, respectively the ubiquitous technologies and apps that constantly check, monitor, test, assess, value and judge us.

Strava

To design his drawing of Italy and later share it with others as itinerary, René Koppert uses the Strava app. Strava is a social network for runners, cyclists and triathletes.[11] With the Strava website and mobile app, users can track their activities and share and compare their performance with other Strava users. The app, used by both professional and amateur athletes, is free but offers paid subscriptions with additional features.

Founded in San Francisco in 2009, Strava is one of the last independent fitness trackers. Other trackers are developed or purchased by technology companies such as Apple (Apple Health), Fitbit (Fitstar), Google (Google Fit), Microsoft (MSN Health & Fitness), Nokia (Nokia Sports Tracker) and Samsung (Samsung Health), or sportswear companies such as Adidas (Runtastic), Asics (RunKeeper), Nike (Nike Training Club) and Under Armor (Endomondo, MyFitnessPal, MapMyFitness). For technology companies, it is lucrative to collect behavioural data from their users as they can link this data to saleable advertising space. For sportswear companies, it is lucrative to know where which sports are practiced, by whom and in what way. As Kevin Plan, CEO of Under Armour, said in an interview with *The Financial Times* in 2015 after his company purchased three fitness apps: 'We now have the world's largest digital health and fitness community. We believe ultimately this will help us sell more shirts and shoes, reach more athletes, and make them better.'[12]

Strava is not yet profitable and has raised venture capital to compensate its expenses.[13] The company adopts a different economic strategy than its competitors with roots in technology and sportswear. In 2013, Strava published a Global Heatmap showing the aggregated and anonymized activities of its users. The map sparked the interest of city planners and transport services, for whom it provided a unique insight into cyclists' movements through their cities. Traffic movement recording is a common method used by planners, but Strava's dataset provided a unique opportunity to access many movements, at different times of the day, including routes and speed. In 2014, this culminated in the creation of a new company: Strava Metro sells Strava users' data to work with cities to improve infrastructure for cyclists and pedestrians.[14] With the commercial venture Strava Metro in mind, Strava's Global Heatmap is more than a map that allows users to 'discover new places to be active',[15] above all it presents a showcase of the technical and commercial capabilities of the company and the data it can offer.

René Koppert uses the Strava Global Heatmap for sports activities. In his case, if he goes to unfamiliar places, he uses the Heatmap as a source of information to discover popular bicycle routes. On the other hand, for local cycling tours, he uses the Heatmap to help him avoid roads frequently used by other athletes.

Not only does Strava passively track data for Strava Metro, it also actively encourages users to collect data outside of their leisure activities and share this information. In 2016, Strava invited cyclists to participate in the Global Bike to Work Day Challenge. It also launched the #CommutesCount campaign. A short animation accompanying this includes the message: 'Traveling with Strava makes cities better.'[16] While Strava encourages its users to collect and share data, users have the possibility to opt out. The app's default setting, however, is to accept sharing of user data and users have to make a real effort to disable tracking in the app's settings—which most do not.

The Strava Global Heatmap became controversial in January 2018, when a military analyst discovered that the map displays the location of secret military bases.[17] Ironically, GPS—the technology that lies at the basis of fitness apps like Strava—was originally a closed-off military technology that was later made available for civilian use, partly to support the developing US commercial GPS equipment and service industry. After the discovery of the sensitive information about the locations of secret military bases, the discussions in the news media focussed on the privacy of users of social media and the power of technology companies like Strava, Facebook and Google to track our behaviour and use it to control our lives.

Expressive Self-Tracking

Not all self-tracking practices are taken up voluntarily. Deborah Lupton, professor of sociology at the University of New South Wales, Sydney, identifies five different modes: private, pushed, communal, imposed and exploited self-tracking.[18] In the case of the Strava app, a variety of these types can be observed. Many individual Strava users will use the self-surveillance app to collect information about themselves, raise self-awareness and optimize their lives.

Since Strava is both a fitness tracking app and a social medium, the focus of the tracking goes beyond the individual user. Users are part of a community of trackers. The platform enables the comparing and sharing of data with other members. Another form of communality is the message Strava puts forward in its Commutes Count campaign. In an animation for the 2017 campaign, users are persuaded to take responsibility for their city and take part in an event: 'Every time you commute on Strava you create anonymous data. The data show urban planners how to improve your city. Commuting by bike is good for you anyway. Now it's good for your city too.'[19]

As mentioned above, the Strava Global Heatmap revealed the locations of secret military bases because the personnel on those bases were recording their activities. It is ironic that some military personnel were given the devices to track their activities by the army itself. In 2013 the US Army provided some of its personnel with fitness trackers to promote a healthier lifestyle.[20] Lupton calls this mode of self-tracking, where the initial incentive does not come from the user, pushed self-tracking.[21] Or even imposed self-tracking if the benefit is only to the advantage of others than the user.[22]

Exploited self-tracking are those practices where personal data of users are repurposed for the (commercial) benefit of others. This is the case when Strava Metro sells the behavioural data of users to cities. One could argue that in the anonymized aggregated data it is not possible to find the data patterns of individual users. However, hacking practices and instances where datasets have been combined to uncover secrets show that the boundary between personal small data and anonymous big data is blurry at best, and non-existent at worst.

Where should we situate René Koppert's self-tracking practice in Lupton's categorization? The recording of leisure activities to track and improve his physical well-being could be classified as private self-tracking. Since Koppert uses Strava and shares the activities with other users of the fitness app, it can also be classified as communal self-tracking. Although Koppert does not have an open profile where his activities can be accessed by everyone, he does share his activities with a small group of followers that he has given permission to do so. If Koppert does not feel the pressure of fellow athletes to keep track of his data, then his practice cannot be classified as pushed self-tracking. And if Koppert has not given Strava permission to use his data, then exploited self-tracking is not the correct classification either.

Koppert's GPS drawing fits into a larger group of practices aimed at expressive self-tracking. There are specialized practices like that of artist Jeremy Wood, who has been using GPS technology to create drawings since 2000.[23] But also practices of non-specialists who express their ideas through GPS drawing in their leisure and fitness activities. The American Claire Pisano, for instance, publishes on Instagram under the moniker @dick_run_claire GPS drawings of penises projected on urban cityscapes that she draws through running. Her drawings are both an expression of fitness culture, the position of Western women in the twenty-first century, and contemporary US urbanity.[24] The website strav.art lists more than 3,000 GPS-drawings categorized by subject in categories such as Elephants, Food & Drink, Plants, Sport and Words & Numbers.[25] The Geography section lists about 75 drawings of the contours of countries and continents, including nine maps of Italy, among which that of René Koppert.[26] Another category on the strav.art website is Burbing, drawing all of the roads of a suburb.[27]

Lupton's categorization feels limited in situating GPS drawing practices. The public nature of the drawings shared on social media, either by the original creator or by followers who recreate the drawing, extends so much further than the term community suggests in communal self-tracking. Koppert's Italy drawing also received attention outside the group of cyclists he is part of when it was shared online and reported in a newspaper.[28] In the case of GPS drawings, there is also the aspect that these self-tracking practices aim to create an image, or write text, that expresses a thought or feeling intended by the creator to be seen by others. For these practices, I would suggest extending Lupton's classification with the category expressive self-tracking.

Post-Representational Cartography

In the text above I have addressed Koppert's practice but not yet his map. It could be argued that the contour of Italy that Koppert cycled is not a map but an illustration, a picture. This reading ignores that the drawing is a 'diagrammatic representation of a piece of land'[29] and that the image, and digital GPX file behind the drawing, can be used as an itinerary or to navigate an environment. With the mere red line on the Open Street Map base map, Koppert's contour of Italy perhaps lacks the visual qualities of the rich cartographic heritage. It is more the action that made the line, and the skill with which it was created, that are appealing. Understanding and appreciating Koppert's map requires an approach that places less emphasis on what the map shows visually and more on the process behind it.

To situate René Koppert's Italy contour drawing as a map, I propose to use a post-representational approach. Post-representational cartography, a term coined by British-American geographer John Pickles, understands a map as a process rather than an object.[30] According to this approach, maps are never fully formed and their work is never complete, they are in a constant state of becoming. A map is constantly being made and remade, every time a user engages with it. According to this approach to cartography, the binary division between making and using no longer applies.[31] Since Koppert first shared his map on Strava in 2020, the route has been cycled 650 times.[32]

When approached as a process, it is interesting to consider at what moment the production of a map ends.[33] Is it when it is conceptualized, when it is embedded in other content on a page, when it is loaded on the screen of a digital device, when it is read, or maybe never? Similar considerations can be made when contemplating the use of maps. When is it first used? During the process of creation, the moment when the mapmaker sees the whole through the fragments? Or, in the case of Koppert's map, the consideration is whether the map was created when it was designed on the computer, or when the route was cycled? This also applies to the use of the map, was Koppert the first user when he saw the contour line appear on the map in Strava, when the map was shared as an image via WhatsApp, or when the route was cycled by himself, or others?

As the term 'post' in post-representational cartography suggests, it is a phase in the thinking about maps. Earlier stages are representational and more-than-representational cartography. Representational[34] or cognitive cartography,[35] developed after the Second World War, has as its premise that the world can be objectively known and truthfully mapped. Cartography develops by using controlled scientific experiments to improve the way a map communicates.

At the end of the 1980s, ideas from poststructuralist thinking, social constructionism and actor-network theory caused a shift in the thinking about maps. In more-than-representational[36] or critical cartography,[37] maps are seen as the product of power, but also as producing power themselves. Mapping is not objective or neutral but charged with power, where knowledge is not revealed but created.

The early 2000s saw a third shift in thinking about maps. In post-representational cartography, the fundamental status of a map is questioned. Maps are seen as a process and never fully formed. In previous ways of thinking the map was regarded as diverse, rhetorical, relational and complex, but nevertheless a stable product. The terms ontological and ontogenic have been used to describe the difference between post-representational thinking about mapmaking and the two earlier approaches.[38] Ontological refers to how things are, ontogenetic to how things become. The map has an ontologically safe basis in representational and more-than-representational cartography: a map is a map, and it is constant. Post-representational cartography questions that ontological basis and looks at the entire mapmaking process. This approach, which examines the entire process of production and use, and all its overlap and intermediate forms, makes it particularly suitable for considering maps in the digital age, in which the distinction between making and using is sometimes vague and often non-existent.

The three different approaches to cartography described above are based on distinct epistemological methods. Representational cartography uses quantitative methods from cognitive psychology. Methods from textual and linguistic deconstruction are used in more-than-representational cartography. The process-based approach to post-representational cartography uses a variety of methods, including genealogies, ethnographies, ethnomethodology, participant observation, observant participation and deconstruction, to capture the full scope of how a map is created and produced, and how social, embodied, political and economic relations play a role in this messy process.

This Way

There are clear parallels between Stanley Brouwn's work of art *This Way Brouwn* and the GPS drawing of the contour of Italy that René Koppert created. Both are maps that involve non-specialist mapmakers. Both projects are intended to be shared with a larger audience, one in an art exhibition, the other on social media. Where the projects differ is the authorship and degree of completeness. Brouwn's work has a clear author: Brouwn himself. From stamping the work, giving it a title with his name in it, and by displaying it in a context that matches his position as an artist, it becomes clear that he is the creator of the map, even if he did not put the lines and street names on the sheet of paper. The work can be repeated, and Brouwn has done that several times, but after it is stamped and exhibited it is complete. With Koppert's map, the issue is more ambiguous: there is no final version of the map, the map is recreated every time someone views the image or travels the route. This also makes its authorship less clear. Not only because there are several GPS drawings of Italy in circulation, but mainly because the map is an ongoing process and not a finished product.

This makes Brouwn and Koppert's projects typical of the technological periods in which they were made: the analogue era in which Brouwn worked, and the digital era in which Koppert created his map. Ambiguity of authorship and degree of completeness are aspects of both maps. But where Brouwn's work is limited to questioning these aspects, with Koppert's map the ambiguity about the creation and status of the final object is fundamental and total because the map is an open process without a clear beginning or end. That is not to say that Koppert's map has only advantages over Brouwn's analogous version. The openness of process and the ambiguity between making and using has downsides. The digital tool will eventually limit and constrain the user.

American social scientist and professor emirata at Harvard Business School Shoshanna Zuboff formulated three laws of surveillance.[39] First, everything that can be automated will be automated. Second, everything that can be informed will be informed. And third, every digital application that can be used for surveillance and control will be used for surveillance and control, irrespective of its original intention. It is especially this third law that comes into play in the practices of GPS drawing where technology companies share apps and services with users in return for behavioural data. Knowledge about where and when athletes do which activity is profitable when you sell advertising space or sneakers, and this explains why tech and sportswear companies are providing fitness tracking apps to users for free or for a small fee. It is not yet fully clear how venture capital-funded Strava will exploit user data. The app with which Koppert made his Italy drawing might be acquired by a tech or sportswear giant, or by a completely different type of company with more problematic intentions than selling ads or sportswear.

More generally, the use of mobile devices is vulnerable to all kinds of surveillance practices. Documents leaked in 2014 by former National Security Agency contractor Edward Snowden show that US and UK intelligence agencies intercept and store Google Maps searches on smartphones with the location information from where the search was made. This was so successful that a 2008 document points out that it basically means that anyone who uses Google Maps on a smartphone is working in support of the intelligence services.[40]

In addition to these surveillance issues, users of self-tracking tools only have freedom within the limits set by technology companies. There are several examples of tech companies choosing to restrict the capabilities of their products for economic reasons or under pressure from states.[41] Every tool reflects the choices of its maker and their thoughts about how it should be used. The more extensive the tool, the more drastic the curation of its functionalities and thus limiting the possible outputs. This calls for awareness and for developing strategies to undermine and hack the digital tools that we use in our lives. In that respect we can learn from Stanley Brouwn who, by not picking up the pencil himself, was able to circumvent the conventions of his field, and thereby hack the work of art as format.

The powerful technology companies monopolize and centralize the technologies that enable us to find our way, to express ourselves by recording our activities and to share these with others. Self-tracking technologies control how we view the world and the data we thus generate is exploited as raw material for economic gain. By being aware and developing subversive strategies, we can determine our own ways, otherwise we will become casualties of the tools that we can no longer do without.

Notes

1 For more information on the work of Stanley Brouwn, see: Antje von Graevenitz, '"We Walk on the Planet Earth": The Artist as a Pedestrian: The Work of Stanley Brouwn,' translated by Ruth Koenig. *Dutch Art and Architecture* (June 1977), https://www.impossibleobjectsmarfa.com/ fragments/stanley-brouwn, accessed 12 June 2022.
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3 René Koppert cycled for TI-Raleigh (1982), Termolan-Gali (1983) and Santini-Conti-Galli (1984), and was the winner of the prologues in Tour de Romandie and Critérium du Dauphiné Libéré and a stage in the Tour of Germany.
4 Interview with René Koppert on 15 April 2022.
5 Erik Dekker (1970), professional cyclist from 1992 to 2006, winner of four stages in the Tour de France, Amstel Gold Race, Clásica San Sebastián, Paris-Tours and Tirreno-Adriatico.
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THE DIGITA

THE DIGITAL CLOUD: BETWEEN GEOLOGICAL EXTRACTION AND METEOROLOGICAL HYPER-RESPONSIVENESS

Natalie P. Koerner

Introduction

Data doubles, space data, weather data, search histories, archived chats and reddit threads—it seems that the digital cloud is striving to become a representation and a record of the planet and its events, with no innate hierarchy of importance or meaning. The digital cloud is thus becoming ever vaster, like Borges's 1:1 map of the empire, but in four dimensions.[1] Its conceptualization, like the metaphor 'cloud', takes on planetary dimensions.[2] The Internet itself has become a complex, global ecosystem. And like the planet, it is not free. The digital cloud is largely owned, mined and administered by transnational corporations, who steer users' political opinions and taste in consumption via microtargeted content and consistent nudging. And yet, access to the digital cloud also represents an important privilege: the digital divide became especially clear during the coronavirus pandemic, when a study found that almost half of the world's population has no access to the Internet.[3] Lacking Internet access means missing important basic resources, such as medical information and financial opportunities. As the Internet continues to expand to encompass more users, it is worth paying attention to and potentially adjusting the structure of knowledge production, archival practices and mechanisms of expansion of today's Internet. Specifically the digital cloud, an elusive metaphor for the data centres that store much of the Internet's data, is an important site of investigation. For most users, data centres are physically inaccessible and shrouded in contrived secrecy, also through the obfuscating use of the term 'cloud'.

The proposed article explores the spatialities, materialities and temporalities embedded in the metaphor of the digital cloud and the data centres it denotes. I will investigate the spatiality of the digital cloud as a voracious and extremely responsive entity. Describing and unpacking the cloud through planetary analogies makes its mechanisms of data harvesting, transmission and archival more concrete and accessible. One important informant is the meteorological cloud, and how it visualizes or models a large array of environmental parameters. A second focus for this investigation is the materiality of digital technologies that form the physical backbone of the metaphorical digital cloud. How does the materiality of the cloud and its reliance on earth minerals, extraction and climate politics reveal innate colonialist injustices? This materiality contains archival qualities already inherent in the geological ground, prior to its extraction.

An Alien Cloud and Non-Conscious Cognition

The digital cloud is so murky and inaccessible to most users that it could just as well be an alien entity that has descended from outer space to hover above planet Earth. Imagine a universe-travelling gaseous conglomerate that now scans the atmosphere for any radio signals emitted on our planet that it can intercept and modify to communicate in any language, visually and aurally. The cloud synthesizes, processes and stores immense amounts of information, unhindered by bonds to location or form. The described entity—as similar as it sounds to today's digital cloud—is the intelligent, communicative and interplanetary alien protagonist of the renowned astronomer Fred Hoyle's 1957 science fiction novel *The Black Cloud*.

This interstellar gas cloud, even though it is mostly characterized as wise and benevolent, is also a ruthlessly colonizing force that extracts energy and information from any entities it crosses. As the black cloud approaches Earth to harvest the sun's energy, an ice age descends upon the planet: Hoyle conjures imagery of frozen tropical forests in complete darkness, icy oceans of petrified wave crests, and a myriad of cadavers scattered under the looming and incomprehensible cloud body. Like the digital cloud and its high energy consumption, the black cloud's presence entails an environmental catastrophe for planet Earth. And like the digital cloud, the black cloud is data-hungry. Its first intelligible reply to a direct message containing the basics of Western science, mathematics and the English language is voracious and impatient: 'Message received. Information slight. Send more.'[4] And like the digital cloud, which promises endless storage and computing capacities, the black cloud's brain and memory can grow infinitely, as it plants intelligence in suitable gas clouds wherever it encounters them: 'And the logic of brain-building seems to have some relation to our programming of a computer,' observes one of the characters.[5] Like the condensed water of meteorological clouds, the black cloud's neurological structures are arranged on the surfaces of miniscule solid bodies—aerosols—of the gas, plasma and dust that compose interstellar clouds.

Pre-empting the apprehensions associated with the machine-learning algorithms of the digital cloud, data is absorbed by the black cloud in a way that proves incongruous with human cognition. And thus, the novel ends with the death of the human protagonist, scientist Dr Christopher Kingsley, who had insisted on attaching himself to a kind of telepathic communication device built according to the instructions of the cloud.[6] Kingsley's brain cannot assimilate the knowledge structures transmitted by the cloud and he dies from relentlessly increasing mental disruption.[7] Similarly, cloud users often perceive the world of Big Data as problematic because the complex workings and seeming autonomy of machine-learning algorithms are untransparent and incomprehensible. As she develops a 'cloud ethics' that treats algorithms as ethicopolitical entities reflecting the social and technical milieu in which they operate, political geographer Louise Amoore acknowledges that 'the most widespread concern in public and scholarly discourse on the operation of algorithms in society is that they are unaccountable or that they cannot meaningfully be held to account for harmful actions'.[8] Further, the sheer immensity of data accumulated and extracted exceeds the human imagination.[9]

However, the digital cloud's processes are not as alien from human cognition as they might seem. Machine learning refers to computer systems (software applications) that harness algorithms and statistical models to increase their accuracy at predicting outputs while updating these with new data. In literary critic and theorist N. Katherine Hayles's reasoning, cognitive processes in such technical systems resemble human cognition. She suggests that we have exteriorized—not the intelligence associated with our conscious thought processes (artificial *intelligence*)—but rather our non-conscious cognition. Thus, biological and technical cognitions are now 'deeply entwined'.[10] The non-conscious scans environmental signals, patterns input and filters what requires the attention of consciousness and uses the information to anticipate future events.[11] Non-conscious cognition is most immediately related to the world and a body's material activities as it directly processes raw data. Non-conscious cognitive activities are akin to those that govern cloud computing, archiving and processing. Hayles explores non-conscious cognition as an activity that humans, technical systems and all other organic beings alike engage in. The non-conscious proposes the more inclusive, post-anthropocentric categories of 'cognizer' and 'non-cognizer'. Separating cognition from consciousness opens up a rich field of information processing that is independent of a sense of self.[12] The non-conscious thus overcomes the Cartesian dichotomy between the adult human who *thinks* and all other non-thinking entities, including children and animals.

A comparable approach was taken by a contemporary of Descartes, who lived in 'an age when the geocentric and anthropocentric view of reality was breaking up'.[13] Yet unlike Descartes, Renaissance philosopher Tommaso Campanella (1568–1639) did not separate the adult human conscious 'I' from the surrounding world. Instead, in Campanella's inclusive understanding, the whole world is a perceptive entity pervaded entirely by just one common spirit. This *sensus rerum*—sense of things—'can be found in every thing'.[14] While perceiving a certain quality, the sensing entity is permeated by the perceived quality: if I touch fire with my finger, then my finger becomes hotter. Stones sense when they are magnetically attracted to one another, the air senses warmer temperature and rises in response, plants sense the sun and turn towards it. I will now show that clouds in all their manifestations, beginning with the meteorological, can be imagined as a large, 'extremely sensitive animal'[15] in the Campanellian sense, as they mutate continuously to visualize everything they *sense*: the geology they float above, the temperature, materiality and reflectivity of the ground, the winds, the cosmic rays, atmospheric pressure, and the myriad chemical interactions among the aerosols they transport. Their responsiveness resonates with Hayles's non-conscious cognition, which describes a direct and immediate engagement with the world. And similarly, it resembles the algorithm's continuous 'engagement with the world'.[16]

Meteorological Clouds Are Analogue Computers

To some extent, all earthly meteorological clouds store data like the black cloud, retain the sun's energy, and harvest and transport resources from all over the world. Whether they are anthropogenic or naturally occurring, clouds mediate data and signal information. For example, smoke-signal clouds are an ancient long-distance communication method[17] and volcanic eruption clouds transmit news of geological events. Meteorological clouds are omnipresent as they continuously cover 67 per cent of the planet. And yet, clouds remain fundamentally elusive: they are unmappable, and difficult if not impossible to model digitally or predict accurately, because they respond to and model immense amounts of data.

Clouds occur when water droplets condensate on aerosols. Aerosols—fine anthropogenic or naturally occurring solids and droplets, also known as 'seeds' or cloud condensation nuclei—are found in the tropo- and stratosphere. They are miniscule, usually smaller in diameter than a human hair.[18] Aerosols travel on air currents for four to seven days and reach speeds of around 5 m per second. There are many different types of aerosols that are produced on the planet's surface, for example, oceans are veiled by a thin mist of salt and sulphates produced by whitecaps and microalgae, Africa's northern half is often covered in Saharan dust particles and black carbon particles enter the atmosphere where there are wildfires. These aerosols differ in their surface topography and chemical composition and interact with one another, which affects their ability to seed clouds, determines when the cloud precipitates as rain, and how much heat it retains or reflects. Aerosols can be understood as data points that infuse the atmosphere as well as the lungs of all breathing entities with physical information from all across the planet. Just as the black cloud stored data on aerosols, the data carried by meteorological clouds constitutes their materiality and affects their spatial formation. The random correlations and vicinities of aerosol data—such as Atlantic Sea salt crystals and Saharan dust next to factory exhaust soot that merged with mushroom spores—is representative of the digital cloud's information structures.[19] Like data in the digital cloud, the continuously transforming and moving aerosols in a meteorological cloud compose ever new adjacencies and juxtapositions. These chance correlations and unrelated thematic vicinities differ from the static spatial coherence between information and a corresponding chronological temporal order of pre-digital archival.[20]

Besides aerosol composition, the extremely responsive morphology of clouds continuously visualizes many changing parameters, such as the phase behaviour of water, atmospheric pressure, land formations below, wind speeds, temperatures, nearby ships and aeroplanes. Clouds were therefore difficult to classify, until pharmacist and amateur meteorologist Luke Howard (1772–1864) presented a nomenclature for clouds in 1802. Howard understood that clouds were the 'visible signs of vast atmospheric processes'.[21] His basic categories—cirrus, stratus, cumulus (and later nimbus)—therefore reflected atmospheric processes rather than the resulting cloud shapes. Today's long-term observations of cloud patterns, enabled by Nasa's Terra and Aqua satellites, show the clouds' responsiveness in ever more detail. For example, wave clouds—large V-shaped fields of alternating clear and clouded strips—form above tall icebergs or islands. These comparatively small elevations push circulating air masses upwards where they meet higher-travelling air. The bands visualize the co-presence of air masses of different temperatures and moisture content.

This example actualizes mathematician and inventor of early mechanical and programmable computers Charles Babbage's idea of the air as an archive. Babbage (1791–1871) declared that 'the air itself is one vast library'[22] of all the words that have been spoken, and all the winds and currents that have acted upon it. His view of the air as an archive was informed by a computational logic. According to Babbage, when we speak, we set airwaves into irreversible motion, affecting every atom of the atmosphere and changing their trajectories forever: 'The waves of air thus raised, perambulate the earth and ocean's surface, and in less than twenty hours every atom of its atmosphere takes up the altered movement.'[23] The air in Babbage's view is an archive as much as a predictive tool. Given enough computational power, knowledge of the air's behaviour and the causes acting on it, the atmosphere's past and future trajectories could be deduced.[24] The air, according to Babbage, is a visualization of the forces that act on it, just as the clouds are responsive visualizations of extensive information and processes.

Considering the modelling capacity of clouds and their continuous updates, meteorological clouds can be thought of as analogue computers. While digital computing relies on discrete units of ones and zeros, analogue computing, prevalent until the 1940s, evolved out of calculation devices and modelling technologies to provide 'continuous representation and physical analogy'.[25] For example, the Moniac, a famous example built in 1949 by Bill Phillips, modelled the UK's financial market. It was a large-scale, wall-sized model of tanks, tubes and pipes that represented different funds, monetary institutions and players. The hydraulic flow was mediated by valves and pumps representing the movement of money. Analogue computers were important tools in early meteorology. In 1918, influential meteorologist Lewis Fry Richardson (1881–1953) used a bowl of water spinning on a gramophone to model the rotational movement of the atmosphere (while serving as a pacificist ambulance driver at the Western Front).[26] These spinning bowls were fairly common. In 1929 at the United States Weather Bureau, meteorologist Carl-Gustaf Rossby used a 2-m-wide saltwater bowl with different dyes to model thermal currents. Ludwig Prandtl (1875–1953), remembered for his research on aerodynamics, created an entire rotating room, 3 m in diameter. Clouds as analogue computers model—or *compute*—the planet by continuously reconfiguring to manifest the conditions of the planetary assemblage of competing parameters. Modelling is the fundamental premise of climate and weather studies, which attempt to assimilate 'many interlocking systems, including the atmosphere, the oceans, the cryosphere (ice and snow), land surfaces (soil, reflectance), and the biosphere (ecosystems, agriculture, etc.)'.[27] As analogue computers, clouds respond to and model these entangled phenomena more accurately than any digital model could.

The Digital Cloud, Electronic Colonialism and the Geology of Archives

The digital cloud shares characteristics both with the colonizing, expansive black cloud and the extremely responsive, data-visualizing meteorological cloud. The digital cloud amasses and transmits vast amounts of data—while some of this data has become indispensable for communication, navigation, knowledge making and governance, much of it is entirely incomprehensible and unused. The cloud is a metaphor for data centres, where the data is stored. These centralized administrative and archival units, operated by large corporations, are situated in large, nondescript and entirely inaccessible boxes that contain an environmentally controlled accumulation of servers. Only cleaning, security and maintenance teams—often 'imported' temporarily for cost and work efficiency—get to enter. From here, cables transmit the data either via cables or wireless connections out into the world.

Even though digital data is often organized according to a meteorological logic and transmitted via microwaves, the world of data infrastructure is decidedly geological. Media technologies consume a large amount of *the ground*—rare earths, minerals and metals, such as cobalt, gallium, indium, tantalum, antimony, platinum, palladium, niobium, neodymium and germanium.[28] The devices on which digital content in data centres is stored are composed of rearranged slithers of geological material. The first layer of a hard drive disk contains platinum group metals and functions as an optimized 'soft magnetic underlayer' for the perpendicular field on which the data is imprinted. Two CoNiFe (cobalt, nickel, iron) layers separated by a four-atom-thick layer of ruthenium constitute this stratum.[29] The next layer is for the magnetic storage. It is made of sublayers of CoCrPt (cobalt, chromium, platinum) alloys. Each material plays a precisely defined role in the reorganized archival strata of digitally deciphered disks: 'The cobalt provides the necessary orientation of the crystals; the chromium improves the signal-to-noise ratio, while the platinum provides thermal stability. Ruthenium [helps to] orientate the magnetic grains, as well as reducing interference between layers.'[30] The information is deciphered by a sensor head that scans the surfaces of the spinning disks layered with magnetic fields of zeros and ones.

The digital cloud is tightly anchored in the Anthropocene (or the Capitalocene), as it relies on data and material mining. If only geologist Richard Alley had been right when he oversimplified the geological ingredients of a phone to foster awareness of the geological materiality of digital technology: 'A cell phone is just a cup of oil, a handful of sand, a few of the right rocks.'[31] Unfortunately, any device that accesses the digital cloud also trails a convoy of gigantic mining trucks or alternatively an army of underpaid (child) labourers, exposed to radioactive collocated materials and collapsing tunnels. 'A few of the right rocks' engender tons of the wrong rocks, which were extracted in labour- and energy-intensive processes. A 'handful of sand' on the scale of the media technology industry entails collapses of riverbanks and of (human and animal) livelihoods. Mining geological material and rearranging it as slick digital devices and invisible infrastructures is an invasive, often cruel, and polluting undertaking. Its by-products are meteoroid sized craters, extensive CO_2 emissions and colonial structures of exploitation.

The reality of the mining industry that supports our digital technologies is as inaccessible as a data centre. Most of us cloud users do not know and cannot find out where the materials of our laptops, phones and the server discs of the data centres that back-up our emails and photos were mined. We do not know if child labour or deadly accidents were involved.[32] A certainty is, however, that some of these materials could be mined in the Western world but are not, because the work is much more expensive if it is done in a healthy, physically sustainable way. For example, rare earth elements are distributed relatively evenly throughout the world, but for many years the West preferred to buy them cheaply from abroad, rather than handle the extremely laborious procedures.[33]

Spinning the metaphor of 'cloud' for the world of big data and its geological materiality further, one could imagine that like the sun, which heats up the ground and causes evaporation of water later visible as clouds, the data economy causes a phase change of the ground beneath our feet to rearrange the extracted material as data carriers. And just as the meteorological cloud condensates on aerosols and thus reflects its material consistency, the digital cloud's morphology represents its corporate owners. 'It matters what thoughts think thoughts. It matters what knowledges know knowledges. It matters what relations relate relations. It matters what worlds world worlds. It matters what stories tell stories,' writes Donna Haraway.[34] Unfortunately, many of the thoughts, knowledges and relations that form the basis of the digital cloud and its geological precipitation are wrought with Western colonialist exploitation, Euro/US-centric values and the Capitalocene. This latter term, unlike the Anthropocene, focusses more on the human-initiated extractive practices of our current geological epoch than on humankind itself.

Under colonialism, networks of extraction were established that still inform the mining industry that supports digital technologies: 'The networks of sugar, precious metals, plantations, indigenous genocides, and slavery, with their labor innovations and relocations ... of peoples, plants, and animals; the leveling of vast forests; and the violent mining.'[35] In today's updated electronic colonialism, these abusive power networks are continued.[36] Critical voices, such as artist and healer Tabita Rezaire, have drawn attention to the spatial relationship between the Internet and colonialism, for example that the 'submarine fiber optic cables that carry and transfer our digital data' are 'layered onto former colonial shipping routes'.[37] In her 2017 video essay 'Deep Down Tidal', Rezaire explains that: 'Electronic Colonialism is the domination and control of digital technologies by the West to maintain and expanse their hegemonic power over the rest of the world.'[38] She elaborates: 'It also operates by sustaining the dependency of former colonized countries on the West, by the importation of hardware, software, engineers, know-how and information protocols.'[39] However, beyond this importation, electronic colonialism is also extractive—in terms of materials, but also in how the mechanisms of Big Data treat all data subjects as mineable for clicking labour and consumption.

The spatiality of the digital cloud is tentacular, like a colonial empire. In Rezaire's words, 'cables are spaces where labour, knowledge and capital sunk into the sea'.[40] And the Internet itself has been described as a series of tubes that sneak their way ever more densely across the planet.[41] I wonder if Donna Haraway's 'tentacular thinking' could serve as a spatial and theoretical antidote to the exploitative nature of the ever-growing infrastructure of cables and the ever-murkier digital cloud. To Haraway, strings and entangled string figures speak of a sympoietic togetherness, where 'human exceptionalism and bounded individualism' have become unthinkable against the reality of 'multispecies muddles'.[42] To Haraway: 'The tentacular are also nets and networks, it critters, in and out of clouds. Tentacularity is about life lived along lines—and such a wealth of lines—not at points, not in spheres.'[43] The ground—that territory of extraction and buried infrastructure—also offers temporal and spatial narratives that remind us of archive and media stories that by far exceed the human horizon.

Accessing information stored on devices of geological materiality conjures a rich history entangled with geostories of the geological ground as an archive and as media.[44] Media scholar Shannon Mattern explores the relationship between geological materiality and the archaeology of urban media: 'For millennia mud and its geologic analogs have bound together our media, urban, architectural, and environmental histories.'[45] Geologist Marcia Bjornerud describes rocks and landscapes as a palimpsest:

Everywhere on Earth, traces of earlier epochs persist in the contours of landforms and the rocks beneath, even as new chapters are being written. The discipline of geology is akin to an optical device for seeing the Earth text in all its dimensions.[46]

Similarly, artist and architecture historian John Ruskin (1819–1900) understood rocks both as paper to be written on by the sculptor-architect, and as archives of the material's own lore and history. In a passage that evokes today's philosophy of elemental media, Ruskin suggests that with increased exposure to the 'language' of marble, the material would soon reveal its archived data and 'even the unsculptured walls of our streets [would become] to us volumes as precious as those of our libraries'.[47] The founders of Western geology, James Hutton (1726–1797) and Charles Lyell (1797–1875), understood the geologist as the decipherer of the planet's archival structure of geological strata arranged across planetary deep time.[48] In his seminal book *The Principles of Geology* (1830), Lyell famously portrays the planet as its own archive-archivist—always changing and keeping track of its own changes. The tempo of geological events reveals archival temporalities, embedded in the geological material, that exceed human temporal horizons. The geological mode engenders spatialities of stratification and thematic vicinity, chronological temporalities and an archival drive to update. This mode is inherent in data centres that harness the archival capacities of geological matter, as data is stored in magnetic fields on data carriers that reassemble extracted geological strata and data transmission is run along cables embedded in the ground and below the sea.

Elemental Media and Leaving the Cloud in the Ground

In conclusion, the global phenomenon 'cloud' is more than a fruitful metaphor for our online data practices supported by data centres and vast infrastructures. The meteorological cloud's morphological responsiveness corresponds to the machine-learning mechanisms of Big Data encompassed by the digital cloud. The geological materiality of data centres harnesses the qualities of the ground as an archival entity. Beyond the cloud metaphor, digital archives and infrastructures are physically embedded in globe-spanning networks of water, earth and air. These natural elements, along with fire, represent the origins of media, as media scholar John Durham Peters shows in his philosophy of elemental media.[49] Like more recent media institutions such as newspapers and the Internet, elemental media are extremely effective at storing and transmitting information. In a similar vein, architect and theorist Keller Easterling suggests an evocative media-infused understanding of the environment, superseding an object-focussed approach to space, where focus is 'given to the medium—to the field instead of the object, the ground instead of the figure'.[50] She sees this shift in perception regarding infrastructural media space as having the potential to lead to a more fluid, adaptable, resilient and real urbanism. Embracing the logic of media would align human endeavours with elemental forces, rather than positioning them in opposition and danger. Changing coastal lines could be a site of potential, not of bankruptcy; hurricanes would generate energy, not just destruction.[51] In a world where humanoid organisms read clouds as a 'wet information system more common than a digital cloud', they might appropriate the air, earth and water as organizational forms, rather than attempt in vain to contain them.[52]

Thinking spatially about the digital cloud with a philosophy of elemental media raises the speculation that it should be possible to simply leave the digital cloud in the ground. Extracting the digital cloud's lithic and metallic matter, along with the archival qualities inherent in the ground, is unsustainable and extremely complex (technologically, politically and scientifically). The finesse to which it is possible to extract, isolate and rearrange on an atomic level minerals and metals for today's digital technologies is astonishing. Would it then not be equally conceivable to develop technologies for injecting data into the ground instead?[53] Further, keeping in mind the shared processes of non-conscious environmental scanning and data processing of organic and technical entities alike, and that all living beings are overlapping 'communities of symbionts', it seems natural to tap into this innate potential, and to bring the data to the ground, rather than the ground into the data centre (after myriad reconfigurations).[54] I join Ruskin who wanted to learn the language of marble, Durham Peters and Easterling who read the clouds, in my hope for a more sympoietic coexistence with the ground and the sky and their rich and dense data scanning, transmission and archival.

Notes

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2 The term 'cloud computing' was developed as an unsuccessful marketing name in 1996 by Compaq marketing executive George Favaloro and technologist Sean O'Sullivan, of the now defunct Netscape. The cloud had made visual appearances since the early 1970s as an icon on maps drawn by administrators of communication networks, to mark an unfixed conglomerate of devices and cable networks.

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4 Fred Hoyle, *The Black Cloud* (Richmond: Valancourt Books, 2015), loc. 2875, Kindle.

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6 Ibid., loc. 3651–3652.

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12 See also the study of 'the sense of being sentient' in: Daniel Heller-Roazen, *The Inner Touch: Archaeology of a Sensation* (New York: Zone Books, 2009).

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14 Campanella, *Compendium physiologiae*, quoted in: Heller-Roazen, *The Inner Touch*, op. cit. (note 12), 171. There are similarities between vibrancy, agency—explored by Deleuze, Delanda and Bennett, among others—and Campanella's understanding of spirit. See, for example: Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC/London: Duke University Press, 2010).

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47 John Ruskin, *The Stones of Venice: The Fall*, iBooks ed., vol. III (London: Smith, Elder, and Co., 1851), 28. On elemental media, see: Durham Peters, *The Marvellous Clouds*, op. cit. (note 17).

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'HERE BE DR

'HERE BE DRAGONS': THE LIMINAL TOPOGRAPHIES OF STATISTICAL IMAGING

Gökçe Önal

> A world does not predate its images. It is shaped by them.
>
> Hashim Sarkis, Roi Salgueiro Barrio and Gabriel Kozlowski, *The World as an Architectural Project*[1]

Nineteenth-century cartographic imagination saw dragons, sea serpents, 'men without heads with their faces in their chests' and many other intimidating beasts of the lands unknown, *terre incognite*, abandon their corners of the Earth—permanently.[2] Popularized by the phrase 'here be dragons', the mapmakers' exotic creatures occupied uncharted territories for centuries until the colonial expansion took hold, ousting the ambiguities and risks associated with venturing unknown lands. Today, the accuracy and detail of digital Earth Engines allow for little surface for such cartographic fiction to take hold, feeding a longstanding rhetoric of omniscience through the seamless 'Google Earth' interface. Yet, as this paper argues, the unknown, the unseen and the liminal continue to thrive within and across the infrastructures of environmental monitoring, without necessarily disturbing the cartographic surface. Resorting to Gayatri Chakravorty Spivak's invocation of 'planetarity' alongside the 'globe', this paper asks: What remains unseen in the regime of ubiquitous surveillance? A media-material reading is engaged for responding to this question on the two operational levels of remote imaging: data gathering and data processing. The resulting framework of spectral and statistical (in)visibilities are further discussed in relation to the production of spatial knowledge.

Introduction: Technoecologies of Images

> In the midst of our serene new world of images, a descriptive revaluation of the conditions of imaging—its technical basis, and the gestures that divide it off from all previous forms of visuality—is a prerequisite for architecture to pose the question, to itself and to culture ... How can we learn to live differently? So differently that we might soon—very soon—become nonmodern?[3]

Exactly three decades ago, William J.T. Mitchell warns his reader of the tendency to (mis)take the electronic image as 'simply a new, nonchemical form of photograph or as a single-frame video, just as the automobile was initially seen as a horseless carriage and radio as wireless telegraphy'.[4] Mitchell's grip remains among the earliest problematizations of electronic surfaces with a 'physical' focus. To date, on the media studies front, scholarship on computational artefacts has gradually arrived at an elemental analysis of media infrastructures[5]—opening up an ecological field whereby questions of the *visual* extends from the screen into the 'deeper material processes' of imaging, or vice versa.[6] Elemental research as such conforms to a 'denaturalized, technologized … and thereby generalized' concept of ecology—a technoecological present, to follow Erich Hörl—that no longer sustains an exhausted nature/culture divide or an alleged 'immateriality' of the digital.[7] It offers here relational ways for attending to our electronic surfaces as a growing-together of intensities, processes, and human and more-than-human agents—'settled temporarily into what passes for a stable state'.[8]

In the case of digital images, the emphasis on emergence and relationality brings into focus a motile *environment* of image objects—broadly the sites of production, dissemination and display through which 'computation is made [visible and] meaningful to us'.[9] In problematizing architecture's cartographic surfaces, I align with Jacob Gaboury's premise that elements of 'visibility, memory, simulation, relation, and history are each inscribed into the technical infrastructure of the medium of computer graphics itself'.[10] An environmentally-attentive reading here reveals digital graphic surfaces to be laden with extractive, reductive and distortive practices that today sustain the most prominent claim to the whole Earth and continually shape the visual economies of technoscientific narratives.

Imaging Infrastructures and Architecture's Informational Surfaces

> 'We need to flip the figure and the background, and recognise infrastructures as one of the major planetary agencies we have at our disposal.'[11]

Today, one can't rigorously tackle questions of electronic media without engaging in a geographically distributed assemblage of resources, hardware, sensing and computing platforms, interfaces and human labour. Scholarly attempts to capture the growing complexity of computing infrastructures, of which imaging remains a part, have culminated in the many diagrams of 'sociotechnical' and 'planetary' stacks, and more recently, 'anatomical maps' of automated labour.[12] Varying in scale and focus, all investigations reveal interoperability to be a central requirement of technical systems, to the extent that 'prioritising any of these layers, at the expense of the rest of the stack, places a constraint on developing an accurate understanding of how a digital technology is conceived and works in practice'.[13] All of the layers of the imaging infrastructure—the remote sensing platform and the operating system employed for data acquisition, the type and the volume of gathered data, the algorithms and the statistical models used for processing data, the software application language, and at the outset, the interface and user interaction—perpetually co-constitute one another in the production of spatial knowledge.

The contemporary momentum of image production and screen labour have rendered computer-processable imagery a currency in design cultures. Architectural thought, reflexes and practice today are increasingly embedded in the graphic surfaces of this 'statistical-electronic' topography—a categorical term that will be adopted here, after John May, for referring to digital images.[14] To date, scholarship on the (in)visibilities of statistical-electronic display has extensively focused on pixilated censorship and blanked-out satellite imagery, no-fly-zones, aerial camouflage, counter-surveillance practices and adversarial attacks—which, with the exception of the latter, conforms to a problematization of interface irregularities.[15] Of interest here, however, is not so much the censorship or curated misinformation, but rather the infrastructural layers into which the physical world is reduced, averaged, filtered and distorted before it is rendered as visual information. What gets lost—or cannot be transferred—in the act of sensing, processing and modelling Earthly energies into statistical-electronic objects? Setting out on this question, two lines of inquiry are defined: spectral (in)visibilities of sensing platforms, and statistical (in)visibilities of algorithmic modelling. The following response is structured around Spivak's invocation of 'planetarity' alongside the 'globe', which offers here a productive ground for attending to the gaps between the represented and the lived.

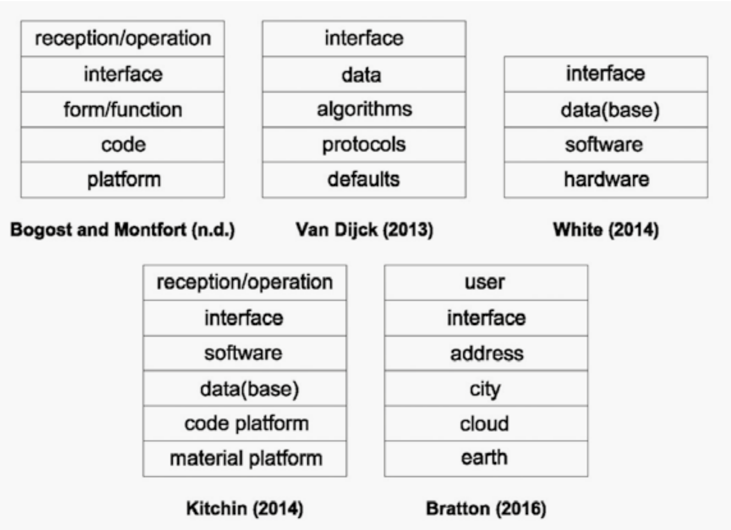

Fig. 1 Examples of 'digital technology stack' concepts from literature. Diagram adapted from Rob Kitchin, 'From a Single Line of Code to an Entire City: Reframing the Conceptual Terrain of Code/Space,' in: Rob Kitchin and Sung-Yueh Perng (eds.), *Code and the City* (Abingdon, Oxon: Routledge, 2016), 20.

The Globe and the Planetarity

> 'Globalization is the imposition of the same system of exchange everywhere … The globe is on our computers. No one lives there.'[16]

Spivak's invocation of the planet doesn't posit an 'on the other hand' relation to the globe. The distinction, however, is growing increasingly integral to postcolonial studies, particularly for attending to the more-than-human timescales of climate histories. Against a scholarly habit of using the two words interchangeably, Dipesh Chakrabarty recounts the global as 'a singularly human story' and the planetary 'as a perspective to which humans are incidental'[17]—where the latter sustains the former. The globe, in Spivak's words, 'allows us to think that we can aim to control it'; it conforms to universals and standards, to master narratives, to an overarching geopolitical order. 'The planet,' she continues, 'is in the species of alterity'; it captures the globe as well as all things irregular, non-binary or ambiguous that escape its seamless surface, as did the mapmakers' beasts—'and yet we inhabit it'.[18] It is by paying attention to the alterity of the statistical-electronic globe that I problematize here the accelerating regime of electronic visual display—or screen—in architecture.

The Excess of Globalization

The globe is an inherently human construct. The making of its figure is grounded in histories of colonial expansion and trade, as extensively discussed to date—systematically shaped by the instruments of (circum) navigation, mobility and cartography.[19] It is a statistical artefact sustained in 'the gridwork of electronic capital', as Spivak suggests, 'an abstract ball [of] latitudes and longitudes' representing the Earth as a homogenized surface of capital and material exchange. If we then take the globe as 'an integral pictorial metaphor of modernity', following Lukas Likavcan, and its contemporary image as the Google Earth Engine, the distinction between the global and planetary imaginations becomes an infrastructural question—one that brings into focus technics of Earth observation as 'one among many of modernity's optical apparatuses'.[20]

Digital Earth Engines today comprise the visible, screen end of this anthropocentric representation practice—sustaining the state-of-the-art claim to a longstanding European endeavour of imaging the whole Earth. Cultural histories of cosmic views argue that an airminded chronicle of seeing-as-knowing underlies, in the disclosed figure of the globe, this appeal to 'total information awareness'.[21] The epistemological 'authority' of globes and geographical maps rests on this model of absolute visibility.[22] Sloterdijk rightfully defines this condition as a state of 'shadowless[ness]' with no more timeouts.[23] Adorno and Horkheimer call it a 'fully enlightened earth'.[24] For Spivak, it is the logo of the World Bank where no one lives.[25] In either instance, the globe of globalization is a human artefact, illuminated to the degree of 'overexposure' in the process of its making—from the surface of which, as I'll argue, the trivial, non-profitable and non-extractable remain eliminated.[26] This paper locates the cartographic unseen in this overexposure act, attending to the realm of the technically eliminated through Spivak's invocation of planetarity vis-à-vis the globe.

'If globalization is characterized by excessive visibility,' Elizabeth DeLoughrey suggests, 'planetarity provides a means to think through—but not necessarily to represent—that which is rendered invisible.'[27] DeLuoghrey invokes Adorno's and Horkheimer's cautionary take on the 'fully enlightened earth' as an imperative for the visual economy of colonialism—the exploration, observation, mapping and ultimately distribution of all life 'peripheral to modernity', including its people, resources, fauna and flora.[28] Excessive illumination understood as such is deeply embedded in (a Western mode of) knowledge production—for surveying practices remain at the forefront of imperial growth and land exhaustion, as postcolonial scholarship has extensively shown. To reiterate a well-travelled but equally important point here, the image of the globe conforms to the mechanisms, technics and standards that have been historically instrumental in making the modern world, which today fundamentally informs the prominent technologies of visualizing the planet.

The problem resides not so much in the fact that the globe is an abstraction of the planet, but that it is a 'very poor' one. It conforms to a *uni*versal claim incapable of engaging a planetary profusion, for 'the planetary … cannot be grasped by recourse to any ideal form'.[29] Spivak's genius in coupling planetarity with the globe lies in defining this gap, through which, as Auritro Majumder argues, she 'invokes a relationship between the human and the natural worlds that is in "excess" of capitalist globalization'.[30]

In what will follow, I'll engage this 'excess' by addressing the—chronic—limitations of the (statistical-electronic) globe in sustaining planetary diversities, and discuss the implications of this gap for the production of spatial knowledge.

Spectral (In)visibilities: Reducing Life to Numerical Means

'A planetary thinking is primarily an imperative for diversities.'[31]

Contemporary planetary imagination is fundamentally shaped by a distributed and diverse operation of remote, or increasingly so, geo-sensing. Geo-sensing today has become a hypernym for the many practices of Earth observation. By design, (geo-)sensors always operate as part of a data acquisition system, either spaceborne, airborne, UAS or terrestrial. The sensing platforms involved in the task abide by different operational parameters for receiving and measuring environmental stimuli, comprising systems of 'detectors, signal conditioners, processors, memory devices, data recorders, and actuators'.[32] Regardless of the platform, all electronic sensors work by 'receiving a stimulus and responding with an electrical signal'—stimulus here implying (radiated) energy, be it optical, acoustic, mechanical or thermal, among others.[33] This practice of 'converting all of lived experience into discrete, measurable, calculable electrical charges (signals)', namely signalization, is examined here as an act of spectral elimination, which brings into focus a multi-layered operation of waves, signals and data conditioning.[34]

The processing sequence involved in remote imaging extends from the acquisition of image data to its calibration, analysis, modelling and integration, which exceeds the scope of any single article. The following discussion focuses on the initial stages of this sequence—namely on aspects of sensor design, data collection and pre-processing—as the site of a dynamic rift between the planetary and its digital abstractions. This rift, understood here as an adjustment and channelling of energies, grows together with a technoecology of signalization, where the incoming stimulus is filtered, divided, converted (into an electrical signal) and is ultimately sampled in digits. The energetic gaps that occur in the process, however, do not simply retreat from sight but simultaneously become part of a continuous subsurface equation—multiplying as approximations, illiteracies and errors along the many sequences of image processing.

Selective Sensibility: Calibrations in Sensor Design and Data Acquisition

Sensor sensitivity (to stimuli) is necessarily a selective constant. By design, any sensor is a partial aperture that only gathers stimuli (that is, radiated energy) from a predefined—and narrow—spectral band, known as its dynamic range. All such calibration involves prioritizing one form of information by physically discarding the others' radiation at the outset, the range of which depends on customer demands. The majority of optical and thermal sensors used in Earth observation include components for further channelling and separating the received radiation into spectral subregions, namely by splitting the signal into narrower wavelength bands through prisms, filters, diffraction grating or spectroscopes before the signal is converted into electric current.[35] In the following stages of processing, the physical segmentation facilitates different channels to be treated individually, which broadly involves operations of correction, feature selection, standardization and dimensionality reduction.

Spectral calibrations are imperative to sensor efficiency, given the wide range of remote sensing applications from climate studies to smart urbanization. Of interest here is not so much the component of feasibility, but a latent practice of 'selective blindness' that has historically shaped the imperial project of resource mapping.[36] Geo-sensing implicitly accommodates technics of resource extraction through the processes of sensing, quantifying, classifying and mobilizing bodies in isolation, deeming certain information redundant in the process.[37] As a practice of elimination, this may broadly involve 'removing pixels unrelated to a particular study … channelling ratios to highlight specific ground feature characteristics … and reducing [data] dimensionality of the image by Principal Component Analysis'.[38] A politics of (in)visibility underlies this process of removal, or the erasure of 'all that doesn't belong to [modernity's] parameters of legibility and certainty', Rolando Vazquez suggests, as much as a disregard of all things unprofitable and in-exchangeable.[39]

> Datafication can't occur without making some forms of information more valuable than others; collecting all of the data all of the time doesn't automatically open out new potentialities for knowledge creation; rather, it solidifies the interests of the actors who are most able to take advantage of it.[40]

The increasing refinement of the sensors' stimulus range today not only multiplies this selective blindness, but simultaneously renders it more precise and processable by systematically eliminating the 'undesired' planetary energy with increasing efficiency. It echoes, following Louise Amoore and Alexandra Hall, an Enlightenment compulsion with a 'stripping away of excess by decomposition and fragmentation for the purposes of control'.[41] Today, technics of spectral and statistical separation, elimination and processing continually intensify a regime of information control by intermediaries.[42] This marks our entry point for attending to the gap between the global (here, the cartographic visible) and the planetarity (here, the unseen).

Unrecoverable Energies: Gaps and Binaries

At the outset of any remote sensing operation, once the Earthly radiation is received by the sensor, the process of electrical conversion allows it to be quantified as a numerical value, relying on the two possible states of electricity moving through a (computer's) circuit: flow or no flow, that is, 'on' or 'off', hence the binary system of 'ones' and 'zeros'. Fed into the base-2 numeral system of computing devices, the received ones and zeros are recorded as patterns of binary digits, more commonly known as 'bits'. A binary code is thus the smallest unit of the—complex—computational language. 'This language is electrical in its nature,' as Jacob Fraden suggests, and 'sensors intended for the artificial systems must speak the same language as the systems "speak" … responding with the output signals where information is carried by displacement of electrons.'[43] The figure below represents the process by which the (continuous) electronic signal received from the sensor is sampled in evenly fixed time intervals and recorded at each sample point as the corresponding (discrete) number.

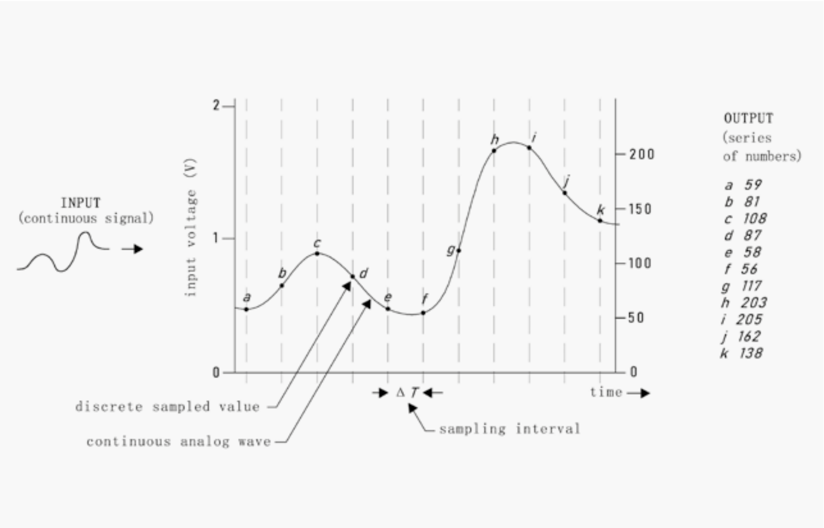

Fig. 2 Analogue-to-digital conversion process. Image drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, Remote Sensing and Image Interpretation (New Jersey: Wiley, 2015), 26.

The conversion of radiated energy here is twofold: first, into an electric current (input voltage), and secondly, into a numerical value (output). The statistical-electrical transfer depicted above marks a critical threshold between what Lucía Jalón Oyarzun describes as 'cartographic overexposure' and its 'remainders'.[44] The diagram renders tangible a physical process of leaving out (the ΔT), as well as the technique of numerical sampling involved in the act. As this conversion always conforms to an 'energy transfer between the object of measurement [and] the sensor', the overexposed—or eliminated—here is understood as planetary life itself, and only secondarily, its visibility.[45] This energetic gap is irreducible and multiplies further into the stages of image processing. May defines the technics of this signalization act as a particular form of memory and storage that is always already quantified, inscribed in the 'gestural-mental routines' of our (cultural) being.[46] However small, the gap—technically—remains intrinsic to the statistical-electronic surfaces of contemporary architecture cultures, to follow May, and ultimately to our ways of thinking and doing (through images).

In her discussion of civic activism within the 'big data optimized [smart] city,' Alison Powell points to this limitation by illustrating how the 'world-making potential of techno-systemic thinking winds its way even into the definitions and potential for civic action'—despite the sensors' technical agency in bringing to light new and multiple ways of knowing. Even in their most dissident, DIY and bottom-up form, sensing practices ultimately support the urban platform model, Powell observes, 'because [they] contribute to the same extractive and calculative dynamics of the big data optimized city'.[47] Processes of electrical conversion, sampling and datafication are technically limited in capturing the breadth of planetary life, energies and spectra. To acknowledge this partiality, I argue, is to renounce the globe-as-a-claim-to-the-whole.

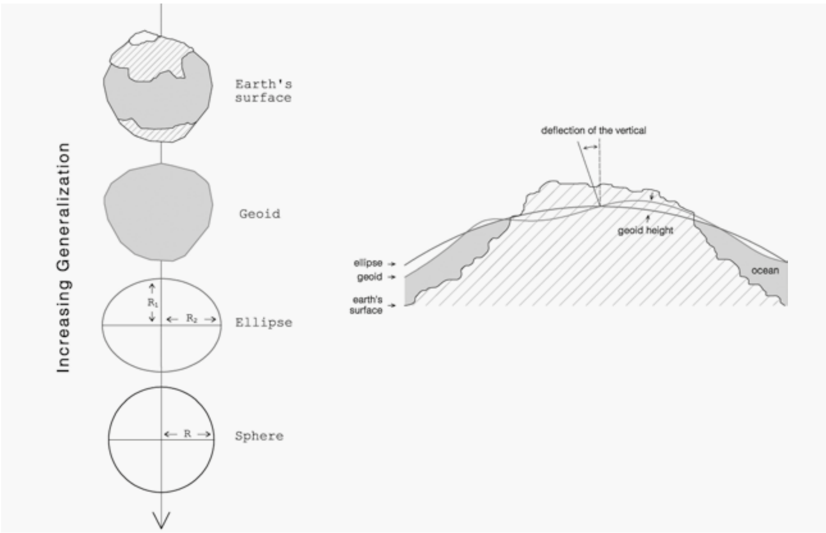

Fig. 3 [left] Modelling the shape of the Earth. Image drawn by the author based on Harrison et. al., *Earth Observation*., Vol. 1A, 56. [right] Deflection of the vertical from the geoid to the spheroid. Image drawn by the author based on *Encyclopædia Britannica, Inc*., s.v. 'geoid', 17 March 2021, https://www.britannica.com/science/geoid, accessed 16 June 2022.

Statistical (In)visibilities: Fitting Life to Standards

As much as the electrical conversion constitutes a gateway to platform interoperability, the integration of the electrical signal into the computer infrastructure hardly remains smooth. By design, a sensor may produce output signals in the form of a voltage, a current or a charge, and these may be further registered as amplitude, polarity, frequency, phase or digital code.[48] The incompatibility of different types of sensors, measurements and platforms grows exponentially into image processing—as 'variability in formats, spatiotemporal granularity, access methods, and differing semantic definitions hinder attempts to ... compare, and combine data sets'.[49] The task is further complicated by a range of (spectral, spatial, temporal or radiometric) errors that are innately present in all remotely-sensed raw data—which may be either platform, sensor and/or acquisition-related, or caused by the Earth's curvature and rotation. Addressing operational interruptions as such requires the observation data to be calibrated at all stages of remote imaging.

In the base-2 numeral system of computing devices, the recorded patterns of binary digits (bits) allow the registered phenomena to be further transmitted, stored and processed in numerical sets. Algorithms and statistical models are designed to convert these datasets into quantifiable outputs with respect to the object space in question. Calibration here involves the application of several correction and standardization models for establishing platform consistency and minimum levels of differentiation between datasets. This is also referred to as homogenization. The task of homogenization—as an attempt at interoperability—brings into focus the infrastructural logic that today, on a planetary scale, 'standardise tendencies and regimes of engagement between bodies in space: postal address systems, languages and scripts, railways, transoceanic cables, time zones, international business standards, cloud platforms, and distributed ledgers'.[50] Remotely sensed datasets are similarly calibrated to pre-defined standards and measurement models for further processing.[51] Regardless of their intended use—agriculture, resource mining, climate monitoring, urban planning, etcetera—all processed image data are registered in present-day infrastructures of data analysis, interpretation and display. The globe is an outgrowth of this standardized, corrected and homogenized infrastructure space (of exchange)—resting on mathematical models of what signals, bands and surfaces, as well as errors and deviations should ideally look like.

Earth to Globe: Approximating Life

Standardization of the Earth's surface as a statistical-electronic ground (for all cartographic and positioning tasks) requires the construction of a global coordinate system—the precondition of which is the accurate measurement of the Earth's size and shape. The operations involved in modelling the shape of the Earth, however, points to a mathematical process of (surface) homogenization, namely a technique of standardization-by-approximation that yields the 'idealized' figure of the globe. Unlike the widespread, spherical imagery of the Earth Engines, Earth's shape is most accurately represented as a *geoid*. The geoid model corresponds to the Earth's gravitational forces, which vary in magnitude and direction due to the planet's irregularly distributed mass—hence the geoid's irregular shape.[52] The following section recounts the algorithmic gestures of modelling Earth by addressing the reductive-distortive instruments of surface fitting (over and under), approximating (by interpolating or extrapolating) and filling (in the blanks).[53]

The geodetic exercise of Earth modelling should be recalled here in the context of post-war Earth sciences and the research programmes initiated during and after the Cold War. Geodesy in the past century came into focus as part of an interdisciplinary endeavour to build planetary models, fuelled by 'the [post-war] availability of instruments and programs that could provide a truly global data set'.[54] This project of 'global model-building' was an imperative for the mid-twentieth century rhetoric of the whole Earth, as Robert Poole suggest, for it not only contributed to the establishment of the planet as a set of integrated systems, reconciling the growing fields of geosciences, but also yielded an interdisciplinary ground for establishing 'the interaction of science and technology with politics, society, economy, and the environment, and ... an integrated mode of thinking about global developments'.[55] Decades-long efforts of accurately reconstructing the shape of the planet thus contributed to 'a new vision of the globe as an integrated political, technological and environmental space'.[56] Here, the military-scientific nexus of the geoid model brings into focus the underlying rhetoric of globalization.

The geoid, as stated above, is considered to be the most accurate representation of the planet's shape and indicates its gravitational potential at any given point. Integral to gravity field calculations is the method of interpolation, namely the statistical estimation of 'unknown values between known values of irregularly spaced control points'.[57] The geoid is hence an interpolated model, bearing an approximated yet highly 'complex undulating surface [that is] impossible to define in simple mathematical terms', proving too irregular for map projections.[58] Earth sciences employ (versions of) the *ellipsoid* model for computational simplicity, which is 'fitted' onto the geoid to substitute the Earth's actual size and shape either locally or globally, and to construct a precise coordinate system to support all cartographic and geodetic calculations.[59] The (approximated) reference surface thus constitutes an elemental precondition of platform interoperability in remote (Earth) imaging. What is ultimately established in the ellipsoid is a standardized, mathematically definable surface that only comes close to the shape of the Earth, presenting a smoother yet more distorted approximation of the planet than the geoid.[60]

The above diagram of 'increasing generalization' begins to render tangible the figure of the globe as problematized throughout this essay: a homogenized surface of 'overexposure', an 'abstract ball', a computerized artefact. Here, the process of refinement is coupled with a distortive dimension—that of approximation-by-interpolation and surface fitting. What gradually appears is not merely the globe-as-an-idealized-model-of-the-planet, but more fundamentally a cultural technique that abstracts the Earth by separating, converting, reducing, approximating and distorting its (gravitational) forces. The alterity moves through these energetic gaps, residues and models as they multiply into the algorithmic construction of planetary images

Civic Life to Statistical Model: Latent Complexities

'The problem of bias has mostly originated from the fact that machine learning algorithms are among the most efficient for information compression, which engenders issues of information resolution, diffraction and loss.'[61]

As monitoring tasks become more specific and multi-layered—and datasets exponentially larger—algorithmic calculations involved in processing and modelling observation data are attributed further dimensions. Broadly, algorithms are finite sets of instructions to be followed in calculations. They are also generative agents that function in tandem, sustaining the building blocks of Artificial Intelligence (AI).

AI is most commonly defined as a pattern recognition mechanism comprising neural and machine learning networks, deep learning, robotics and computer vision. The product of algorithmic computation is a statistical model, namely a cluster of probability distributions. Statistical models today remain at the forefront of big data optimization, including urban innovation platforms. Yet, as existing scholarship has extensively shown, AI is technically limited by (historical, dataset-related or algorithmic) biases, assumptions and weights, which affect city planning and management at various levels of decision making.[62]

'The cybernetic systems that underpin the framework of the data-optimized smart city are intended to reduce complexity in various aspects of city life,' Powell suggests.[63] Optimization in data-driven systems implies a 'capacity to generate an actionable output from a set of attributes', reducing probabilities to one single—optimal—conclusion.[64] And while the 'condensed output' is put forward from a set of 'rejected alternatives', as Amoore argues, 'the branching pathways continue to run beneath the surface'. However singular, the algorithmic output is a fragile and contingent value: shift the weights in the 'hidden layers' and it is modified.[65] At the city scale, this may involve rather mundane instances such as the 'shortest' routes proposed by your navigation software, or dining suggestions made by search-and-discovery apps that align with your previously-visited restaurants or consumer habits—suppressing the non-optimal or less relevant in the process. It may, however, entail sharper consequences such as reproducing the racialized practices of municipal redlining in data-driven planning, as Sara Safransky illustrates. Her work on proprietary market value assessment reveals bias in urban governance to be largely shaped by the categorical choices of algorithm designers—more specifically, by their understanding of social problems, risks, census track analysis, value estimations and investment opportunities, among other things.[66] On various levels of decision making, the statistical reductions, approximations and assumptions multiply into the everyday information infrastructures, comprising today the visual economy of Earth Engines and digital twins.

Conclusion: Emergent Relations

Sensors are capable of making environments 'present and interpretable' across spatial, spectral and temporal scales, to recall Jennifer Gabrys, bringing human and more-than-human subjects and processes into (emergent) material relations.[67] This bringing together, however, is a numerical operation growing on 'unrecoverable gaps'.[68] As this paper illustrated, outside of the planet's statistical-electronic topography lies an excess that is unextractable, non-binary and unprofitable.

The statistical-electronic technics of engaging life bring certain objects into focus and eliminate others by moving earthly intensities such as waves, signals, digits, algorithms and statistical models: comprising a technoecology of images. An elemental reading of (the extents and limits to) electronic sensing here begins to reveal a growing-integral of the seen and the unseen in quantifiable terms. The statistical-electronic unseen—namely the ecology of gaps, residues, approximations and rejected paths—does not imply an absence of surface visibility alone, but itself becomes part of a continuous subsurface equation. The invisible today grows alongside the visible in increasing precision, multiplying into the sequences of image processing and ultimately into our knowledge infrastructures.

Cartographic imagination infiltrates the surface via infrastructural rifts, I argue here, as did the dragons and the beasts. What is left out (of the image) then becomes the function of an accelerating quantification of subsurface invisibilities. The unseen invades the margins of planetary speculation with deepening precision, leaving little room for alternative registers of knowledge production to prosper. The statistical-electronic visible here remains a 'threshold of inscription', rendering the surface a function of numerical weights.[69] It is on these thresholds of the (in)visible that I locate Spivak's planetarity as a means to attend to the 'excess'—understood here as all forms of engagement that have been marginalized from the statistical-electronic regimes of architecture's surfaces, much like the beasts, sea serpents and dragons of other registers.

Notes

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BLOCKCHA

BLOCKCHAIN AND THE REAL-ESTATE-MEDIA COMPLEX

Marija Marić

From the introduction of fractional ownership to the emergence of entire markets for developing and trading digital land, the real estate domain has become the latest frontier for start-ups and companies organized around the uses and promises of blockchain technologies. Since its first appearance in 2008, when a pseudonimously published paper introduced Bitcoin—a digital currency generated and circulated through a peer-to-peer network that promised to revolutionize financial transfers by excluding third parties such as central banks—blockchain has received an almost mythical status of a system that could allow for decentralized and transparent transactions of information in all of its imaginable forms: from money to data, digital cats or real estate shares.[1] And while Bitcoin, and more importantly, the blockchain protocol that underlined it, did involve a technological innovation, still, what brought this technology to the public's attention was a solution to the social coordination problem it proposed. In other words, blockchain 'introduced a practical way of coordinating computational activity *without* explicit and sustained participation, and with unknown and untrustworthy actors'.[2] As a social technology, blockchain thus came in at the right historical moment—the 2008 economic crash that brought with it a final kick of disillusionment with the existing financial and political institutions—and successfully offered an alternative: an unchallenged trust into the objectivity of the machines and a big return of the technological solutionism.

Claiming the capacity to execute data transfers without friction, or more precisely, without people, blockchain was quickly embraced by the real estate industry, still burdened by a strong presence of intermediaries, as well as slow and expensive transaction processes. Coupled with burgeoning land and real estate prices and a growing problem of housing affordability, but never challenging the paradigm of home ownership and private property—the PropTech industry framed blockchain as the latest, go-to disruptive technology that would revolutionize our relationship with the built environment as we know it. Soon, the new technology found its place on the covers of a number of future-of-real-estate reports and articles, advertising many of its potential applications in the property sector.[3]

Thus, for instance, the management of land registers—national systems that store information on the ownership, control and other recorded rights over land—appeared as one of the first testing grounds for blockchain technologies. As a peer-to-peer protocol that makes all transactions of information traceable, blockchain has been hailed as an effective tool both for the easier management of land ownership transactions, as well as for making them more accessible to the wider public, providing a better overview of practices of land accumulation and patterns of speculation. With countries such as Georgia or Sweden, who were among the first to test the possibilities of blockchain on their national land registry systems, it became clear that the promises of full transparency and automation behind the new technology are still a form of a techno- (and legal) fiction. In reality, the shift mainly included digitization of existing land registers and their anchoring onto the blockchain—a process that is still dependant on the power and trust in a central authority, in this case, that of the state.[4]

Offering 'fractional and frictionless real estate investing' and claiming 'ownership reinvented', the Prop Tech market has also seen an explosion of start-ups that specialize in real estate tokenization, referring to the usage of blockchain technology for buying and selling digital real estate shares.[5] Drawing from the history of Real Estate Investment Trusts in the 1960s United States, when REITs appeared as 'financial intermediaries' that allowed 'individuals to invest in real estate and mortgages ... in the same way they can buy common stocks through mutual funds', real estate tokenization effectively utilized blockchain technology to allow the very objects of real estate to be traded in a new way: as a set of fractions that could be bought, sold or rented out, independently of each other, by different stakeholders.[6] In other words, traditional property units, such as an apartment, a house or a plot of land, could now be abstracted into assemblages of digital tokens, each essentially constituting a share, or rather a *fraction* of a given property, detached from any of its spatial or functional aspects. Designed to lower investment thresholds and therefore allow a much broader pool of prospective real estate owners to purchase only fragments instead of entire property units, this shift towards fractional ownership of real estate has been presented by its native industry as a 'democratization' of the non-accessible housing market—a 'paradigm shift' enabled by a blockchain technology.[7]

Next to the management of tangible properties that real estate tokenization and digitization of land registries provided for, blockchain's presence in the real estate domain has perhaps been most commonly associated with an emergence of less physical but equally material forms of property: the non-fungible tokens, or NFTs, referring to the non-interchangeable digital assets, such as images, videos, music and even virtual real estate. One such NFT is the now already famous Mars House, designed in 2020 by a Toronto-based artist Krista Kim as the first digital-only architectural NFT project. Sold for 288 Ethereums (worth approximately half a million US$ at the time), Mars House is now being rented out as a space for virtual events, such as wedding ceremonies or family reunions, serving also as a trigger for a booming architectural and urban NFT market.[8]

Beyond digital houses and singular objects, different companies are also competing in constructing entire virtual worlds operating as new marketplaces for the trade of digital land, real estate and other commodities. Thus, for instance, projects like Decentraland—a virtual reality platform that features 90,000 digital, 16 × 16-m plots of land that each initially sold for 0.1 Ethereums—provide new imaginaries of land speculation, whose value is now grounded solely in the attention economy that powers these initiatives.[9] No matter how intangible the digital land of Decentraland is—traded as LAND tokens and defined only by the unique x, y coordinates of its Cartesian world, as well as a reference to a content the owner wishes to provide on their virtual land—its economies are more than material. In 2021, the Metaverse Group purchased a parcel in Decentraland for 2.4 million US$, just more than half the price of the most expensive piece of virtual land sold in Sandbox (another platform that offers trade of digital properties) for 4.3 million US$ to Republic Realm—one of the largest real estate developers in the Metaverse.[10] The profitable formulas of projects such as Decentraland or Sandbox, however, do not end with their property portfolios, but also feature their own, custom-made cryptocurrencies. Thus, for instance, the digital parcels in Decentraland are traded through MANA, whose market capitalization surpassed 5 billion US$ only four years after the platform's launch.[11]

Similarly, the trade and speculation of virtual land and real estate is not just a matter of digital environments. Projects such as Earth 2.0, designed as a digital twin of the 'analogue' Earth, is split into 5.1 trillion land tiles, 'in which real-world geolocations on a sectioned map correspond to user-generated digital virtual environments', and that, most importantly, can be bought, owned and traded.[12] By mirroring the geography of the physical world, Earth 2.0 and other similar platforms also mirror its on-the-ground geopolitics and systems of value, thus making the projection of power hierarchies and inequalities embedded into these geographies possible. As such, the virtual domain of projects like these appears not as a final destination for the trade of the digital land, but rather as a tool or an intermediary that could shape the value, based precisely on the relationship between the digital and the physical.

The (Spatial) Politics of Blockchain

Drawing its origins from the cypherpunk movement of the 1990s, organized around a belief that technology could serve as an alternative form of governance to that of the state, blockchain has been deeply shaped by the cyberlibertarian political ideologies. As David Golumbia observed in his book *The Politics of Bitcoin: Software as Right-Wing Extremism*, cryptocurrencies have incorporated some of the most basic elements of a right-wing worldview, even if their broader narrative does not immediately relate to the rhetorics of the right.[13] From understanding of the central bank as a 'deliberate plot to "steal value" from the people to whom it actually belongs', to its role in keeping the world on the brink of collapse, and belief that '"hard" currencies such as gold provide meaningful protection against that collapse'—as Golumbia points out, the cyberlibertarian ideology has a lot in common with the right-wing movements, especially in Europe and the United States.[14] By positioning technology as a means of enabling and protecting freedom, and thus framing IT products, services and markets as necessary for maintaining democracy, cyberlibertarianism has successfully aligned itself with the logic of capitalist production. Similarly, and despite its mainstream narrative, the blockchain itself has been eagerly adopted and embraced by capitalist institutions, ranging from various industries to banks themselves, serving as an infrastructure for a more efficient flow of money, trade and speculation.[15]

Blockchain is, therefore, a social technology.[16] In (re)producing power hiearchies and new social relationships, blockchain is an 'inherently political technology', and as such it has helped shape our imaginaries of property.[17] In its most bare form (such as Bitcoin and other cryptocurrencies), it has successfully managed to propagate the social model of a 'techno-Leviathan', where cryptocurrency users 'establish novel forms of social contracts'—the ones in which they 'agree to "contract" with cryptographic algorithms that guarantee their (financial) peace and safety'.[18]

Following from there, blockchain technologies and their discontents, such as cryptocurrencies and NFTs, as Felix Stalder pointed out, managed to produce ‘a trivial version of Adam Smith’s society of independent shopkeepers as “creators”’, creating an ideal model of an ‘ownership society’, in which all social relations are embedded in the logic of private property and distrust in social institutions—a position that could also be seen as central to the current neoliberal economic and political paradigm.[19]

Its extractivist logic, articulated by its language of mining, has also found its place in the real estate domain, itself characterized by extractive practices of growth and profit making.[20] Starting from here, one could ask: How will the wider acceptance of blockchain technologies that facilitate real estate trade and speculation, impact the already unstable values and unequal distribution of land and housing on-the-ground? What is the role of technology in hyper-commodification of the built environment—a state in which, as David Madden and Peter Marcuse observed, ‘all of the material and legal structures of housing—buildings, land, labor, property rights—are turned into commodities?’[21] And finally, which new forms of living and belonging could emerge out of these new relationships between humans and space, and technical and financial infrastructures that communicate between them?

Going beyond current real estate market’s rendering of lived space as square metres, and towards translating real estate into tokens, designed to be easily traded and speculated upon—real estate tokenization has led to a form of abstraction of housing, thus allowing for a new way of seeing properties: as metrical units of money flows, instead of spatial units of habitation. Parasitizing on the existing inequalities embedded in our dysfunctional housing system, PropTech narratives of property democratization through real estate tokenization not only help to maintain the current economic status quo, but also actively contribute to the radicalization of speculative real estate practices. This leads to the question: Does the translation from use-value to trade-value of housing have the capacity to produce another kind of translation: from inhabitants to the new kind of space occupants—a family of real estate token owners?

Similarly, standing on the opposite spectrum of what artist and media theorist Hito Steyerl described as ‘poor images’, referring to the compressed and pixelated free and anonymous digital objects on the Internet, whose condition of circulation and far-reaching dispersion has the potential to redefine the value of an image—NFTs like Mars House are essentially based on the speculative logic of private property and starchitecture.[22] Appearing as ultimate commodities whose value is constructed solely on the grounds of programmed scarcity, the proliferation of architectural NFTs marked a beginning of a new kind of real estate market—the one in which buildings are finally liberated from the burden of the use-value and are instead replaced by images that can be freely traded. With blockchain as ‘the medium in which an artwork is inscribed, valorized, traded, archived, and even displayed’ itself becoming a ‘financial technology’, it becomes clear that ‘digital art practices, then, are themselves currently in the process of becoming financial technologies’.[23] As such, NFTs could essentially be seen as a radicalized form of private ownership that now takes the digital sphere as its new frontier.

At the same time, platforms like Decentraland could be seen tools that are providing us with ideal real estate visions: a grid reduced to a bare spatial organization of economic potential; an urban machine for land and real estate speculation, unconstrained by any regulatory or ethical obstacles. An advanced form of commodification of urban imaginaries, these real estate fictions are also actively shaping material land. The launch of digital twins of Earth, through platforms such is Earth 2.0, not only led to an acquisition rush for digital parcels that geographically correspond to the location of ‘value’ on the ground, but could also easily be seen to work the other way around too—strategically acquiring and developing land in the digital space in order to increase its value in the physical one.

The Possibility of Urban Commons beyond the Real-Estate-Media Complex

The proliferation of ‘real estate products’, such as real estate tokenization, architectural and urban NFTs or the virtual lands of Decentraland and Earth 2.0, depends heavily on the construction of attention, and the cultivation of its economies. Language, in this process, plays a key role. The discoursive language of start-ups and companies whose profit relies on dreams of growth, rather than existing material grounds, operates on a discursive technology, described by anthropologist Anna Tsing as ‘the economy of appearances’, referring to the ‘self-conscious making of a spectacle … necessary for gathering the investment funds’.[24] In other words, and as Tsing suggests, profit must be imagined in order to be obtained. The same goes for the expansive visions of property. Drawing from the language of the housing crisis on the one hand and real estate growth on the other, the PropTech industries have positioned blockchain as a tool for ‘democratization’ of property markets by inventing ever new and more radical forms of private property ownership. In a real-estate-media complex in which architecture, cities and entire urban imaginaries are being produced today, language appears as an alternative construction site, where projects are being built by means of narrative, storytellng and above all, fiction.[25]

In their essay ‘Smart Cities as Corporate Storytelling’, Ola Söderström, Till Paasche and Francisco Klauser positioned smart cities as ‘part of contemporary language games around urban management and development’, devised to position tech and real estate companies who offer smart city products and services as ‘obligatory passage points’ in the ‘transformation of cities into “smart” ones’.[26] Tech-industry’s vision of smartness could thus be seen as an economically performative narrative, and above all a financial model, that ‘allows real estate firms to charge a “smartness premium”, thus driving up already prohibitive costs of real estate’.[27] What started as a ‘smartness mandate’ after John Palmisano’s famous IBM talk ‘A Smarter Planet’, could also be seen as a base for all the iterations of technological solutionism that followed until today, including blockchain technologies as they claim to revolutionize real estate domain.[28]

Asking why, throughout history, philosophers and economists who shaped our common understandings of property so often chose a narrative instead of a scientific approach to making their argument, legal theorist Carol M. Rose suggested:

> We may only be able to understand property arrangements through narrative discourses like literature and history, discourses that construct a story of how things got to be that way—a story in which there were genuine choices along the way and in which things were not really predictable in advance and did not have to wind up the way they did.[29]

Understanding property as a story, it becomes clear that, in order to change the narrative and allow for unexpected twists and turns, we need to rethink who the narrators are. In other words, if the Decentralands of the world are conceived as real estate fairy tales written by companies and developers, could we also imagine the opposite—blockchain technology as a testing ground for imaginaries of another relationship with property, or its undoing altogether? Moving beyond the dichotomy of good and bad technologies, as Felix Stalder pointed out, the question of 'whether the technological potential of the blockchain can be used to advance the social vision of more-than-human commons', remains open.[30]

This reminds us of the fluidity of capital, its modes and sites of reproduction, that once intersected with novel technologies lead to ever-new forms of commodification of the built environment, providing us, at the same time, with the tools and possibilities to rethink the notion of the commons, resistance and critical spatial practices in (and through) the digital domain. In asking, 'what can urban commons learn from the free software hackers?', Dubravka Sekulić observed how 'the digital, more than any other field, discloses property as being inappropriate for contemporary relationships between production and reproduction, and additionally, proves how it is possible to fundamentally rethink it'.[31] Learning from NFTs, LANDs and 'fractional ownership' as new paradigms of private ownership created in the intersection with novel technologies, it also becomes necessary to think of new modes of digital commons these technologies could help outline, seeking, at the same time, their productive relationships with the struggles for urban commons on-the-ground.

In outlining an 'expanded activist repertoire in infrastructure space', architecture theorist Keller Easterling suggested that, in order to effectively counter the complex economic, political and technological forces that stand at the core of production of social and spatial injustice today, we need 'techniques that are less heroic, less automatically oppositional, more effective, and sneakier—techniques like gossip, rumor, gift-giving, compliance, mimicry, comedy, remote control, meaninglessness, misdirection, distraction, hacking, or entrepreneurialism'.[32] In other words, as she further observes, we need an approach 'to both form-making and activism that is more performative than prescriptive'.[33] With media strategists, tech industries and cryptocurrency brokers moving to the forefront of production of both our built environment and collective urban imaginaries, we need to radically rethink and extend the scope of design and research tools in order to reclaim architecture as a critical and political practice, by asking: What is the relationship between the built and the fictional, the Earth and its digital twins, the physical and virtual land, and how are architects to mediate these materialities critically?

Notes

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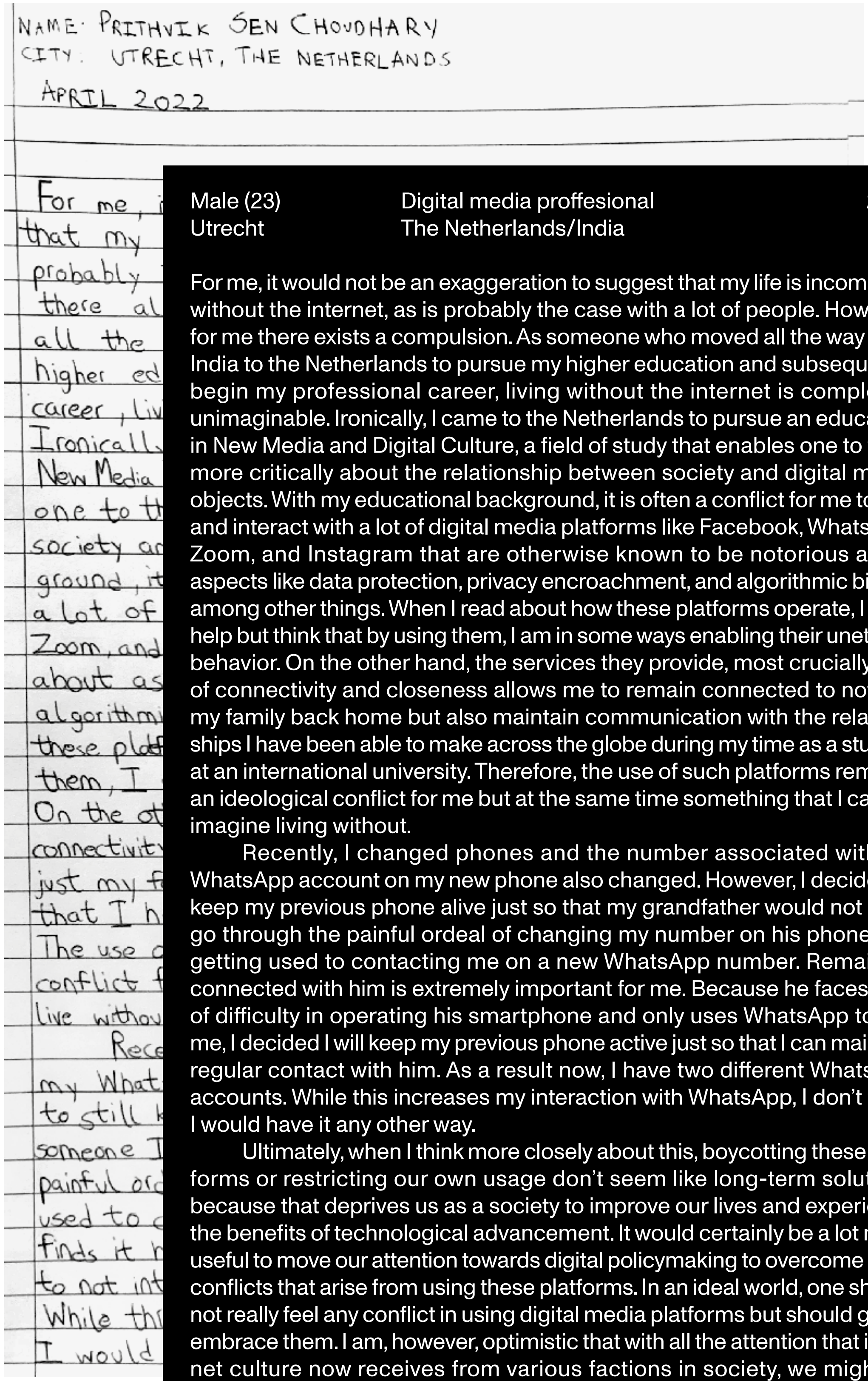
LIFE NEEDS

LIFE NEEDS INTERNET
Handwritten Letters on Digital Culture
Jeroen van Loon

Life Needs Internet is an ongoing project that archives digital culture through handwritten letters. Each letter answers the question: How does the Internet influence your daily life and how does it make you feel? I started this project in 2010 and since then have collected more than 1,500 letters with personal and anecdotal stories from 40 different countries covering a period of more than a decade.

The goal is to preserve the global influences of the Internet through local and personal testimonials. The letters, all handwritten in the author's native languages, have mostly been collected during lectures, exhibitions, workshops and some through the Internet. The larger the archive becomes, the more chance these letters will create an archaeological insight into digital culture, showing how digital culture differs per country, culture and generation.

Every five years (2012, 2017, 2022), I use a number of letters from the archive in a video installation showing the original letters in combination with video portraits featuring the authors. These video installations often focus on newly collected letters. The selection presented here in Datapolis offers a larger overview of the whole archive. It shows three letters from 2010 to 2021 and is a first attempt to dive into the entire archive and construct a larger narrative by means of the individual letters. The selection process was primarily based on the told stories, anecdotes or experiences, while simultaneously trying to ensuring a fair balance between the different years and locations. Lastly, the letters were rearranged in a non-chronological order to avoid any historical or linear narrative, instead composing a series of combinations through the course of time. That way, the three letters react to each other, offering a unique insight into the archive of *Life Needs Internet*.



NAME: PRITHVIK SEN CHOUDHARY
CITY: UTRECHT, THE NETHERLANDS
APRIL 2022

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Male (23) | Digital media proffesional | 2022
Utrecht | The Netherlands/India

For me, it would not be an exaggeration to suggest that my life is incomplete without the internet, as is probably the case with a lot of people. However, for me there exists a compulsion. As someone who moved all the way from India to the Netherlands to pursue my higher education and subsequently begin my professional career, living without the internet is completely unimaginable. Ironically, I came to the Netherlands to pursue an education in New Media and Digital Culture, a field of study that enables one to think more critically about the relationship between society and digital media objects. With my educational background, it is often a conflict for me to use and interact with a lot of digital media platforms like Facebook, WhatsApp, Zoom, and Instagram that are otherwise known to be notorious about aspects like data protection, privacy encroachment, and algorithmic biases among other things. When I read about how these platforms operate, I can't help but think that by using them, I am in some ways enabling their unethical behavior. On the other hand, the services they provide, most crucially that of connectivity and closeness allows me to remain connected to not just my family back home but also maintain communication with the relationships I have been able to make across the globe during my time as a student at an international university. Therefore, the use of such platforms remains an ideological conflict for me but at the same time something that I cannot imagine living without.

Recently, I changed phones and the number associated with my WhatsApp account on my new phone also changed. However, I decided to keep my previous phone alive just so that my grandfather would not have go through the painful ordeal of changing my number on his phone and getting used to contacting me on a new WhatsApp number. Remaining connected with him is extremely important for me. Because he faces a lot of difficulty in operating his smartphone and only uses WhatsApp to call me, I decided I will keep my previous phone active just so that I can maintain regular contact with him. As a result now, I have two different WhatsApp accounts. While this increases my interaction with WhatsApp, I don't think I would have it any other way.

Ultimately, when I think more closely about this, boycotting these platforms or restricting our own usage don't seem like long-term solutions because that deprives us as a society to improve our lives and experience the benefits of technological advancement. It would certainly be a lot more useful to move our attention towards digital policymaking to overcome such conflicts that arise from using these platforms. In an ideal world, one should not really feel any conflict in using digital media platforms but should gladly embrace them. I am, however, optimistic that with all the attention that internet culture now receives from various factions in society, we might be heading towards a more inclusive culture.

いまの実態

私がワメナに初めてやってきたのは１９８１年で、１９９９年以降、２００５年までのほとんどの期間をこのワメナ、およびその周辺の山々ですごしました。そうして２００６年以降、現在までこのワメナでインターネットカフェを営んで暮らしています。

そんな私から見て、パプア人（ここではインドネシア人を対象から除く）とコンピューター、とりわけノートパソコンとの出会いは、彼らの生活に大きな変化を齎しました。これまでのテレビや音楽のない世界から一変し、自分たちの知らなかった世界を簡単に目や耳にすることができるようになったのです。

それではそんな高価なもの（ワメナでのノートパソコンの購入価格は約５００ドル以上。

Male (58) | Internet cafe owner | 2011
West-Papua | Indonesia

Current situation
It was 1981 when I came to Wamena for the first time. For most of time between 1999 to 2005, I lived there and also in the mountains nearby. In 2006, I settled in Wamena and started running an internet-café.

In my point of view, the encounter with computers, especially laptops, has brought a big change to Papuan lives (except for Indonesian). It enabled them to see and hear the unknown world out of the one without TV or music. Why do they manage to get such an expensive thing? (The price of computers is more than 500 dollars in Wamena. Monthly income of public employees is about 150 dollars.) My internet-café in Wamena offers fixing service. More than 2,000 computers are brought in a year. This situation can tell that there supposes to be about 10,000 computers around Wamena, half of which are provided by the government.

Computers have become one of the essential parts of life, but there are some problems.

First, because computers are provided for free, Papuan people don't take care of it very properly. Especially, the life with electric appliances is still new for them, its operation and treatment is a big problem. Second, although laptops give profit to villages in inconvenient areas, most of their electricity supplies (except for Wamena) are dependent on their own generator. Its unreliable electricity supply sometimes damages the inside equipments of computer. Third, people start understanding the basic software such as WORD or EXELE, which are the main purpose to use computer, still there are very few people use or learn Internet and other soft wares.

Vision for the future
It would take much longer time until Papuan people really understand computers and maximize its benefit. Because of a sudden change from the life without books or electric appliances, they look just confused to have the latest technology and eventually sometimes break it. That's the situation for now.

The biggest problem is that people lack the will to be better. I've found out through 4 years experience of running an internet-café that they are easy to forget even very simple operation.

New technology can be easily brought by money, but learning it takes time. Papuan people, who have been away from taking efforts to learn new things, would have to face difficulties from now on.

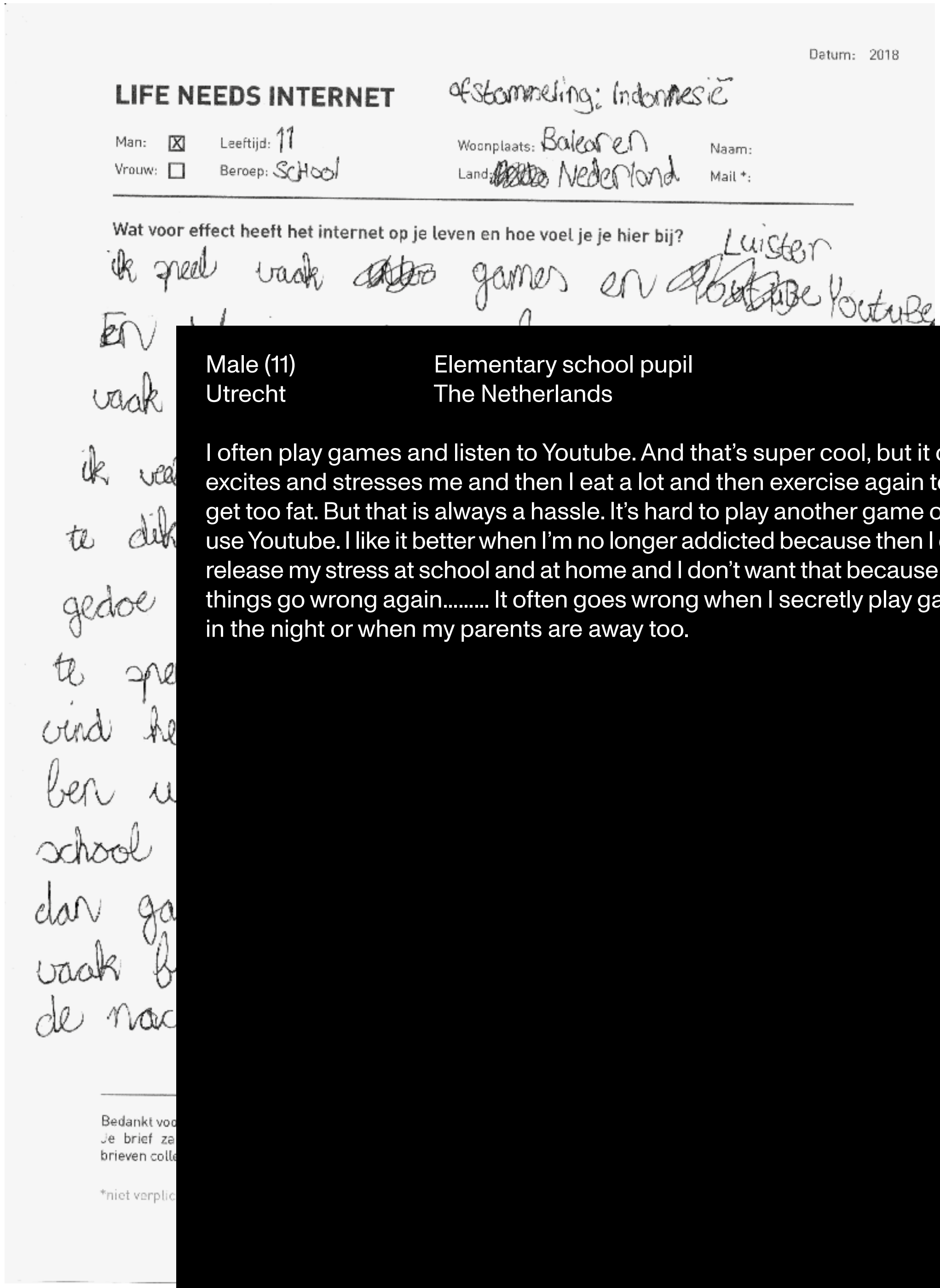
الحياة تحتاج الى الانترنت - توثيق للثقافة الرقمية من خلال رسائل مكتوبة بخط اليد

المدينة: امستردام　　الجنس : ذكر
المدينة / البلد : هولندا　　السن: ٢٥

كيف تشعر حيال تزايد أهمية وجود الكمبيوتر والانترنت في حياتنا اليوم وكيف يؤثر ذلك على حياتك اليومية؟

Male (25) | Art student | 2017
– | Syria/The Netherlands

I remember quite well how the connection to the internet was made by using the regular telephone line… Sometimes we had to wait for an hour or more, before receiving a response… 15 years ago; it took a very long time. Around 10 kilobyte per second, incredibly slow, but at least there was actual contact through the internet. So how is it possible to see everything in a distant part of the world by simply clicking a button? The Internet was actually a symbol of wealth at the time. The Internet was not for everyone. Whether or not you used the Internet depended on your finances and technological possibilities. After a relatively short time, more technology became available throughout the country. The mobile phone and computer were rapidly introduced into every home. It made communication through the Internet much easier. The Internet demanded more and more time both at work and at school, as well as when meeting up with friends. It actually became the way to follow the news. It is also a method of finding out something. Each question was asked on Google. For the majority, the questions were about our lives as Syrians, about what was happening in our country and how we could escape from that high-risk place. Nowadays, we are aware of the importance of the Internet. Even now, it is sometimes difficult to communicate through the internet due to the lack of electrical power and/or the bad connection. The Internet has helped us to understand what we need to do, how we should do it and where we are heading. The Internet is one of the most powerful media that has helped many people to survive. I now remember my first introduction to the Internet some 15 years ago and how it has become an essential part of our daily life. I do wonder what the situation will be like in 15 years' time; will I be living without the Internet?



Datum: 2018

LIFE NEEDS INTERNET afstamneling: Indonesië

Man: ☒ Leeftijd: 11 Woonplaats: Baleoren Naam:
Vrouw: ☐ Beroep: School Land: Nederland Mail *:

Wat voor effect heeft het internet op je leven en hoe voel je je hier bij?

ik speel vaak games en Luister Youtube
En
vaak
ik vo
te dik
gedoe
te spe
vind he
ben w
school
dan ga
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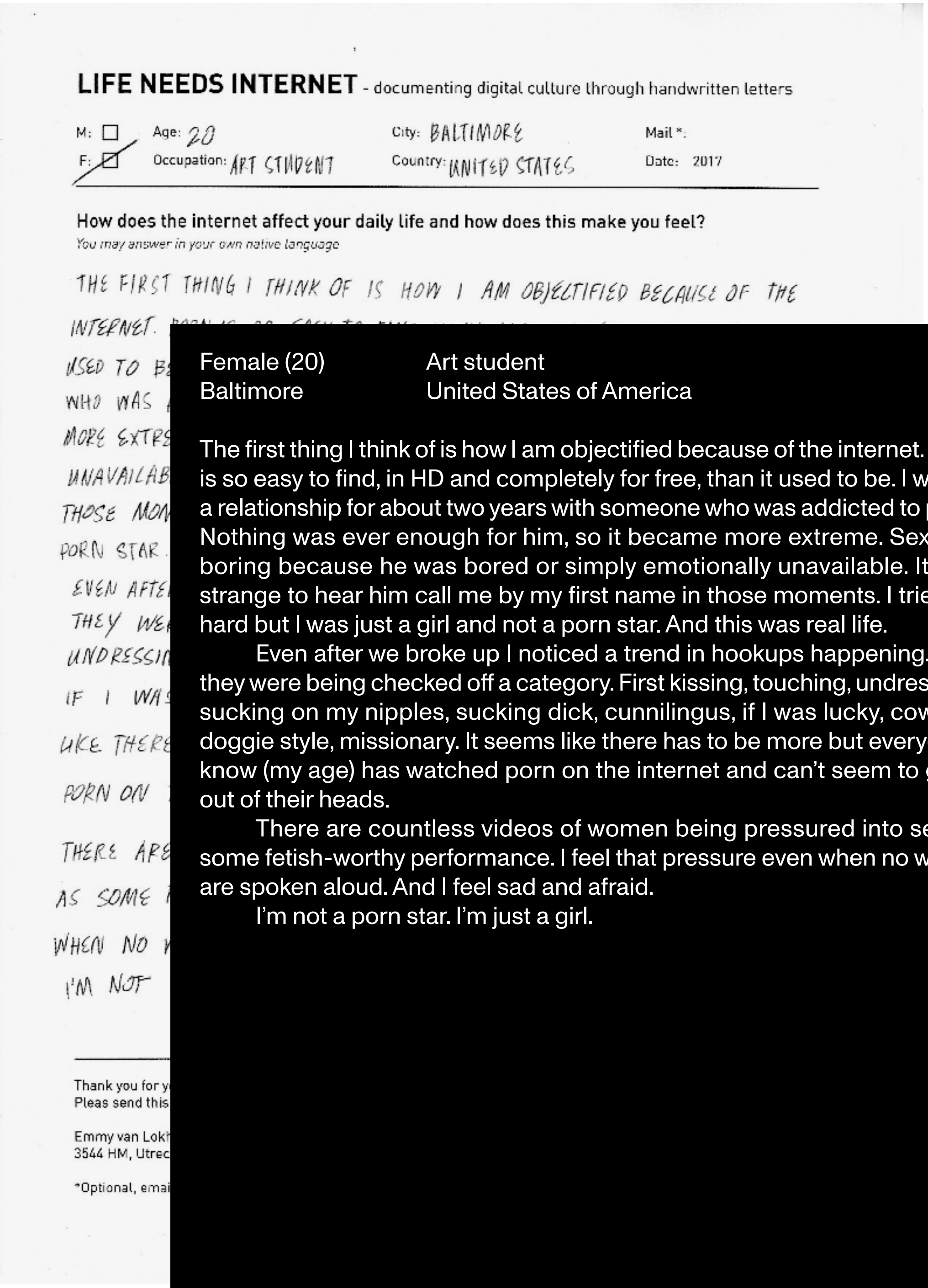
de nac

Bedankt voo
Je brief za
brieven colle

*niet verplic

Male (11) Elementary school pupil 2018
Utrecht The Netherlands

I often play games and listen to Youtube. And that's super cool, but it often excites and stresses me and then I eat a lot and then exercise again to not get too fat. But that is always a hassle. It's hard to play another game or not use Youtube. I like it better when I'm no longer addicted because then I don't release my stress at school and at home and I don't want that because then things go wrong again……… It often goes wrong when I secretly play games in the night or when my parents are away too.



LIFE NEEDS INTERNET - documenting digital culture through handwritten letters

M: ☐ Age: 20 City: BALTIMORE Mail *:
F: ☒ Occupation: ART STUDENT Country: UNITED STATES Date: 2017

How does the internet affect your daily life and how does this make you feel?
You may answer in your own native language

THE FIRST THING I THINK OF IS HOW I AM OBJECTIFIED BECAUSE OF THE
INTERNET.
USED TO B
WHO WAS
MORE EXTR
UNAVAILAB
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PORN STAR.
EVEN AFTE
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PORN ON
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AS SOME
WHEN NO
I'M NOT

Thank you for y
Pleas send this

Emmy van Lok
3544 HM, Utrec

*Optional, emai

Female (20) Art student 2017
Baltimore United States of America

The first thing I think of is how I am objectified because of the internet. Porn is so easy to find, in HD and completely for free, than it used to be. I was in a relationship for about two years with someone who was addicted to porn. Nothing was ever enough for him, so it became more extreme. Sex was boring because he was bored or simply emotionally unavailable. It was strange to hear him call me by my first name in those moments. I tried so hard but I was just a girl and not a porn star. And this was real life.

Even after we broke up I noticed a trend in hookups happening. Like they were being checked off a category. First kissing, touching, undressing, sucking on my nipples, sucking dick, cunnilingus, if I was lucky, cowboy, doggie style, missionary. It seems like there has to be more but everyone I know (my age) has watched porn on the internet and can't seem to get it out of their heads.

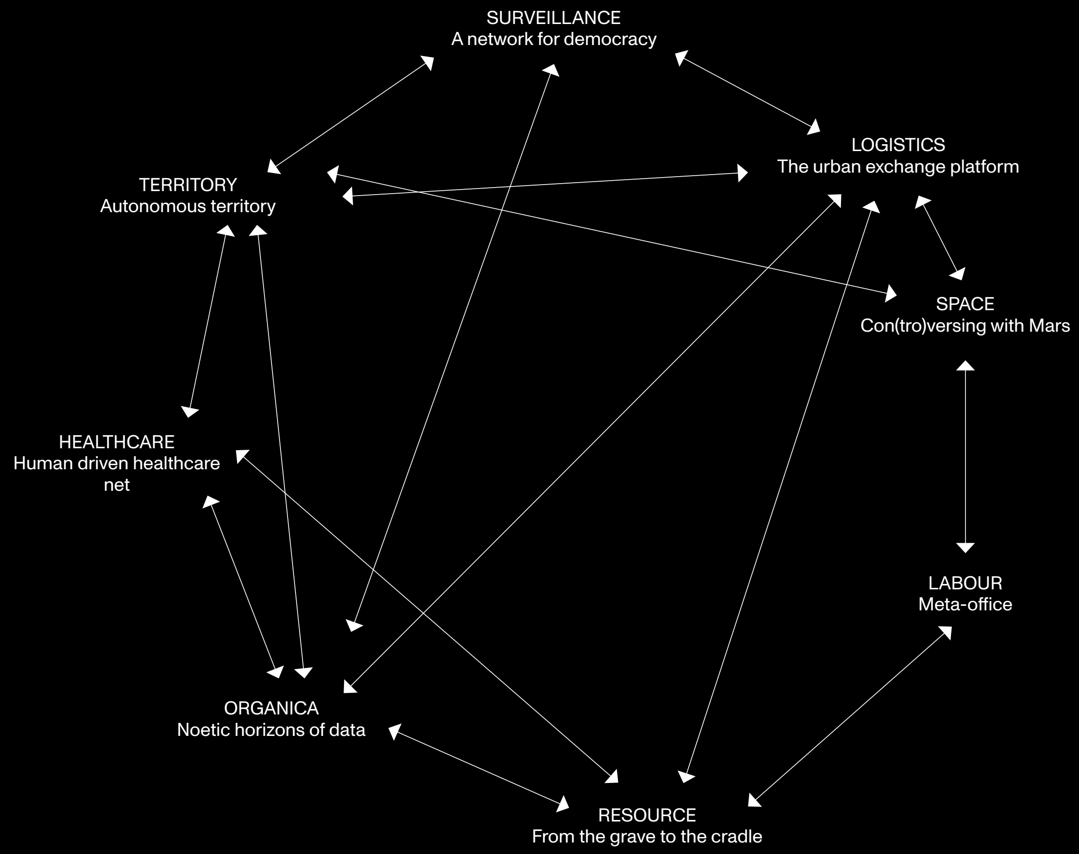
There are countless videos of women being pressured into sex as some fetish-worthy performance. I feel that pressure even when no words are spoken aloud. And I feel sad and afraid.

I'm not a porn star. I'm just a girl.

VISIONS: SP

VISIONS: SPATIAL SPECULATIONS ON HOW TO LIVE WITH THE LEGACY OF DATAPOLIS

Datapolis Studio



SURVEILLANCE
A network for democracy

LOGISTICS
The urban exchange platform

TERRITORY
Autonomous territory

SPACE
Con(tro)versing with Mars

HEALTHCARE
Human driven healthcare net

LABOUR
Meta-office

ORGANICA
Noetic horizons of data

RESOURCE
From the grave to the cradle

AUTONOMOUS TERRITORY

Arda Ertan Yildiz, Wu Yongyi

By the year 2020, about 1.7 megabytes of new information will be created every second for every human being on the planet. As the digital transformation of our society expands, data centers play the critical role of providing the technology backbone that supports our digital lifestyle. In fact, data centers are accommodating these needs by occupying almost two billion square feet of facility floor space across the world.[1]

Due to the huge growth in data demand worldwide, the traditional data centre model has shown its limitations. But from the trends in the data centre typology evolution and geographical distribution, we can see a possibility of a completely independent system. Benefits from advanced computer technology, high-speed networking and artificial intelligence, the next generation of data centres can be close to the most advantageous external factors and develop to the most effective form.

In the research, three main positions have been put forward, which are:

1 In the foreseeable future, global data demand will grow exponentially, just like it has in the past few years.

2 A more intensive (hyperscale) and automated data centre typology will become a necessity for reasons of efficiency.

3 Energy and environment issues that massive data centres bring will affect our world and the data centres themselves.

As a relatively new human invention, the data centre seems to be incompatible with the natural environment and living environment in many ways. A typical example of this is e-waste: the non-degradable or even toxic parts that are the unavoidable consequence of the earth hidden behind the Internet we use.

These trends provoke new possibilities for data centres. Is it possible to better integrate data centres into universal or specific natural systems, or even industrial systems? How can data centres benefit from these natural or artificial environments, for instance by increasing efficiency or reducing adverse effects, and even achieve a mutually beneficial relationship with them?

The project proposes three specific locations for data centres:

A Under the Atlantic Ocean.

B On the outskirts of a city in southern China.

C In the depths of the Svalbard mountains.

The primary consideration in choosing these three locations is that they all have an existing connectivity to the Internet submarine cables: the Atlantic Ocean contains the existing connection between United States and Europe; South China is an important hub for the Pacific Rim; Svalbard has a submarine cable directly connected to Norway in the remote Arctic.

Except for Internet connectivity, each data centre presents distinct characteristics, such as relationship to natural environment, population density, industrial composition, political attributes and so on. These bring about different discussion topics at each location, which can be used to explore the different possibilities and potential adaptability of the data centre.

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[1] Steven Carlini, 'Data Center', Schneider-Electric 2017, https://blog.se.com/datacenter/2017/11/17/data-center-iot-architecture/.

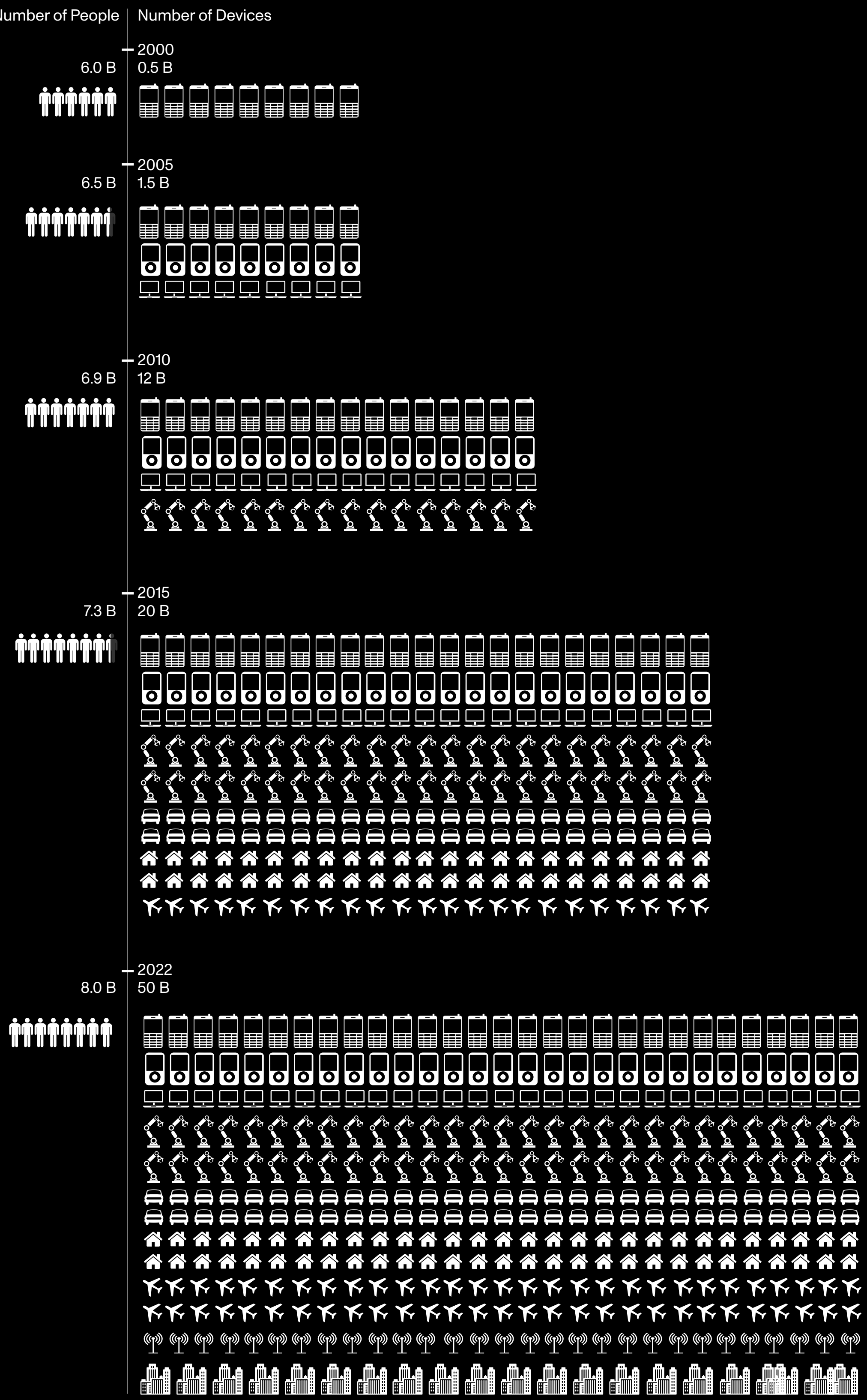


Fig. 1 Population growth versus the increase in number of connected devices between 2000 and 2020. Drawing by Federica Longoni and Filip Promaniuk.

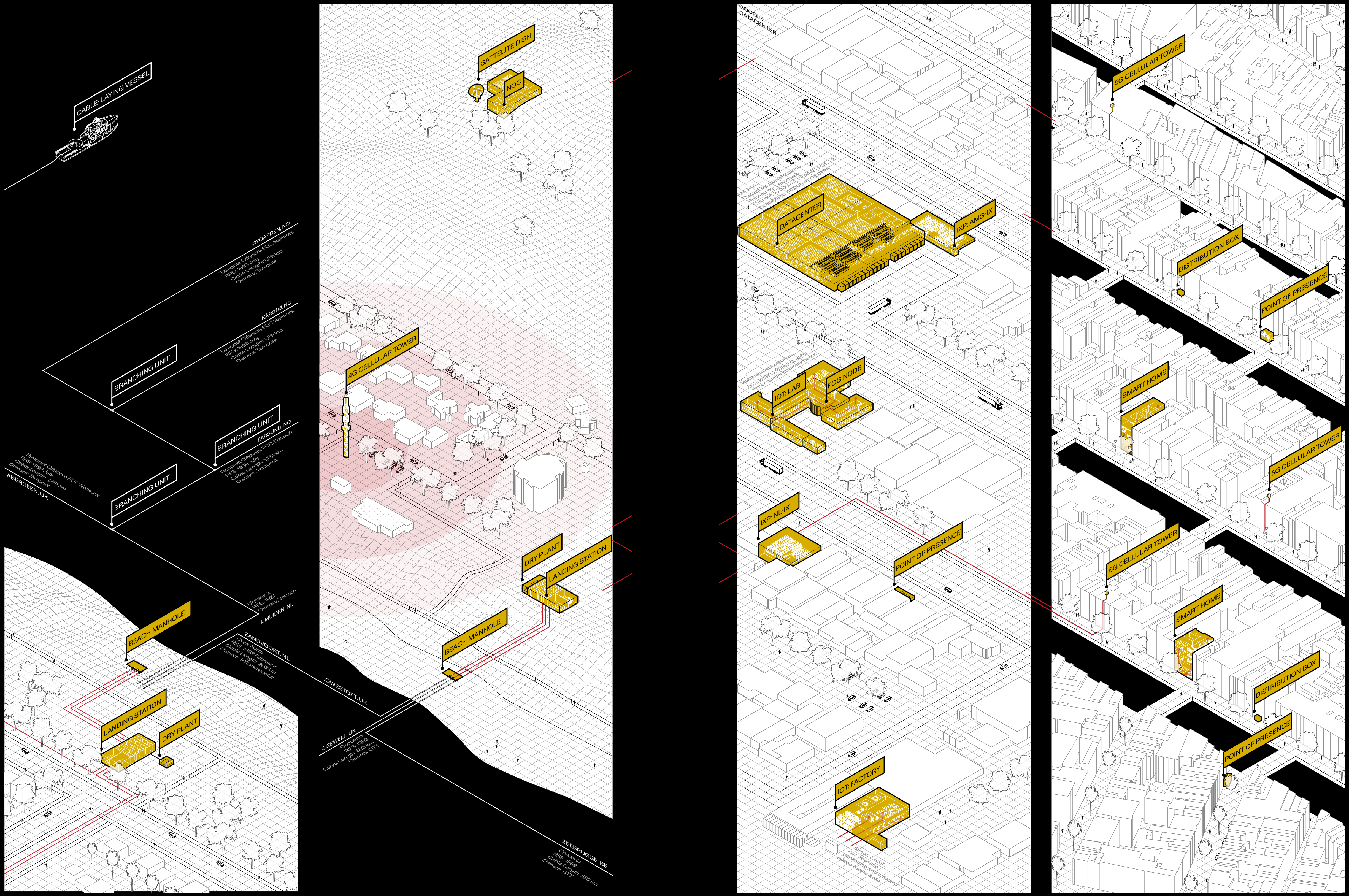
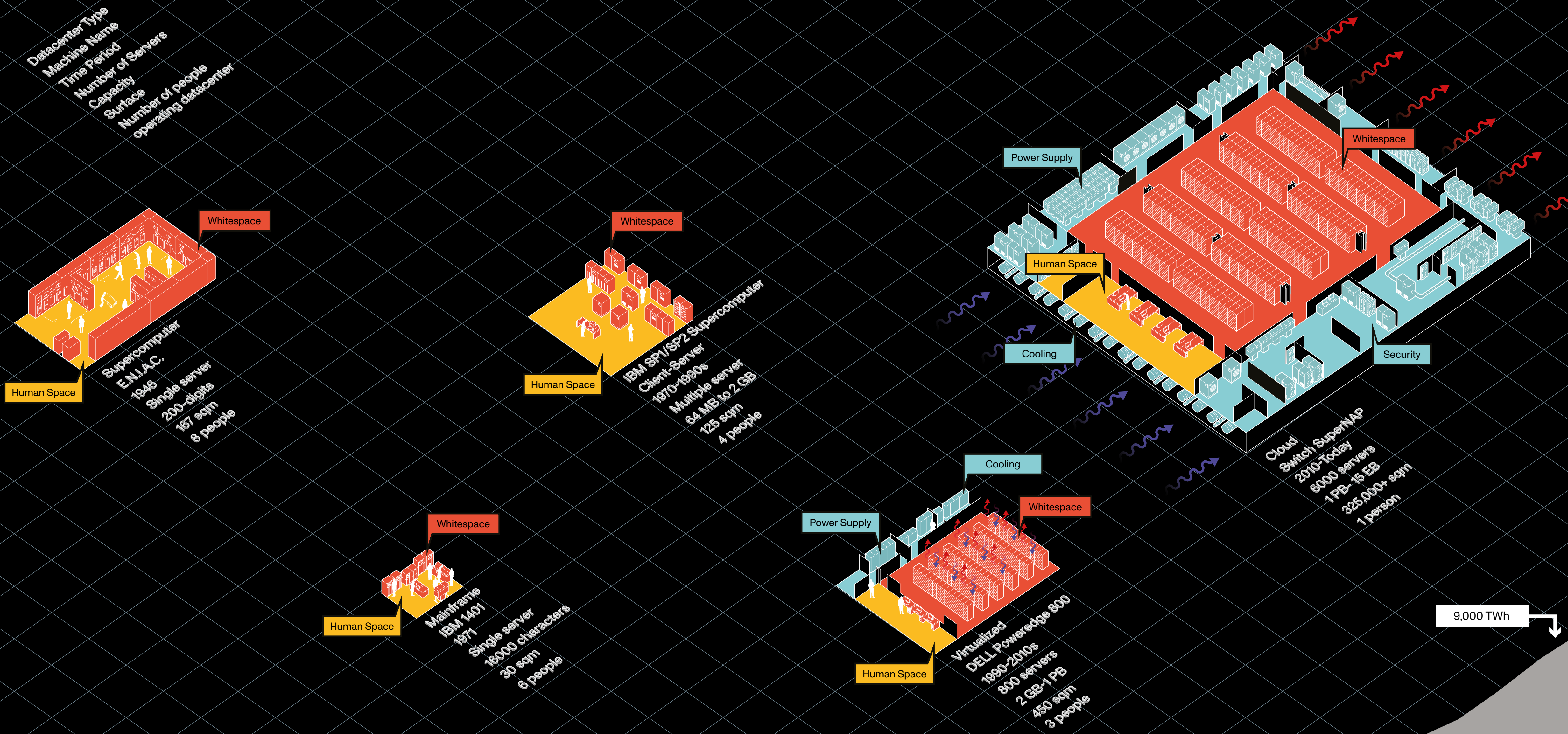


Fig. 2 The Infrastructure of Data: parts of the network and their interconnection.
Drawing by Jasmijn van der Harst & Coen de Vries.



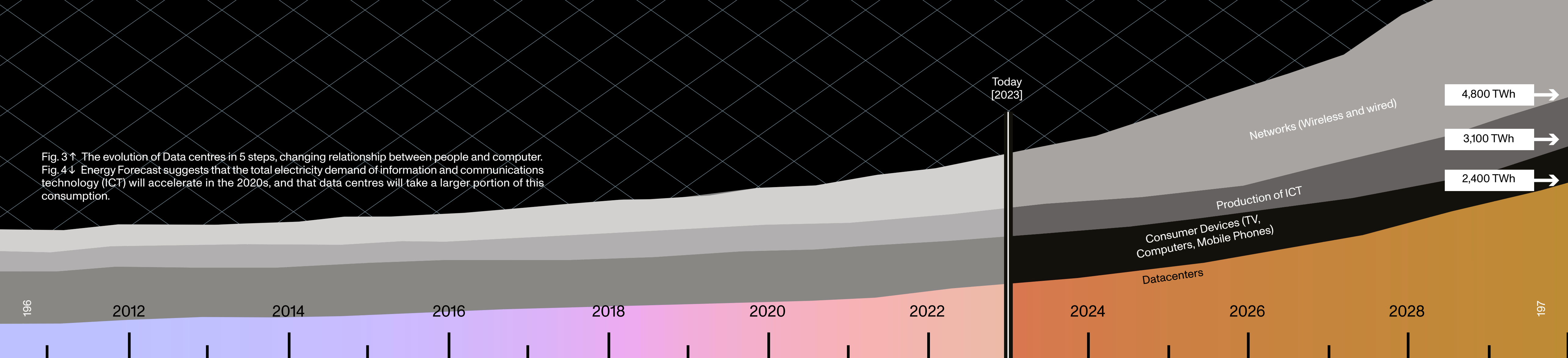


Fig. 3↑ The evolution of Data centres in 5 steps, changing relationship between people and computer.
Fig. 4↓ Energy Forecast suggests that the total electricity demand of information and communications technology (ICT) will accelerate in the 2020s, and that data centres will take a larger portion of this consumption.

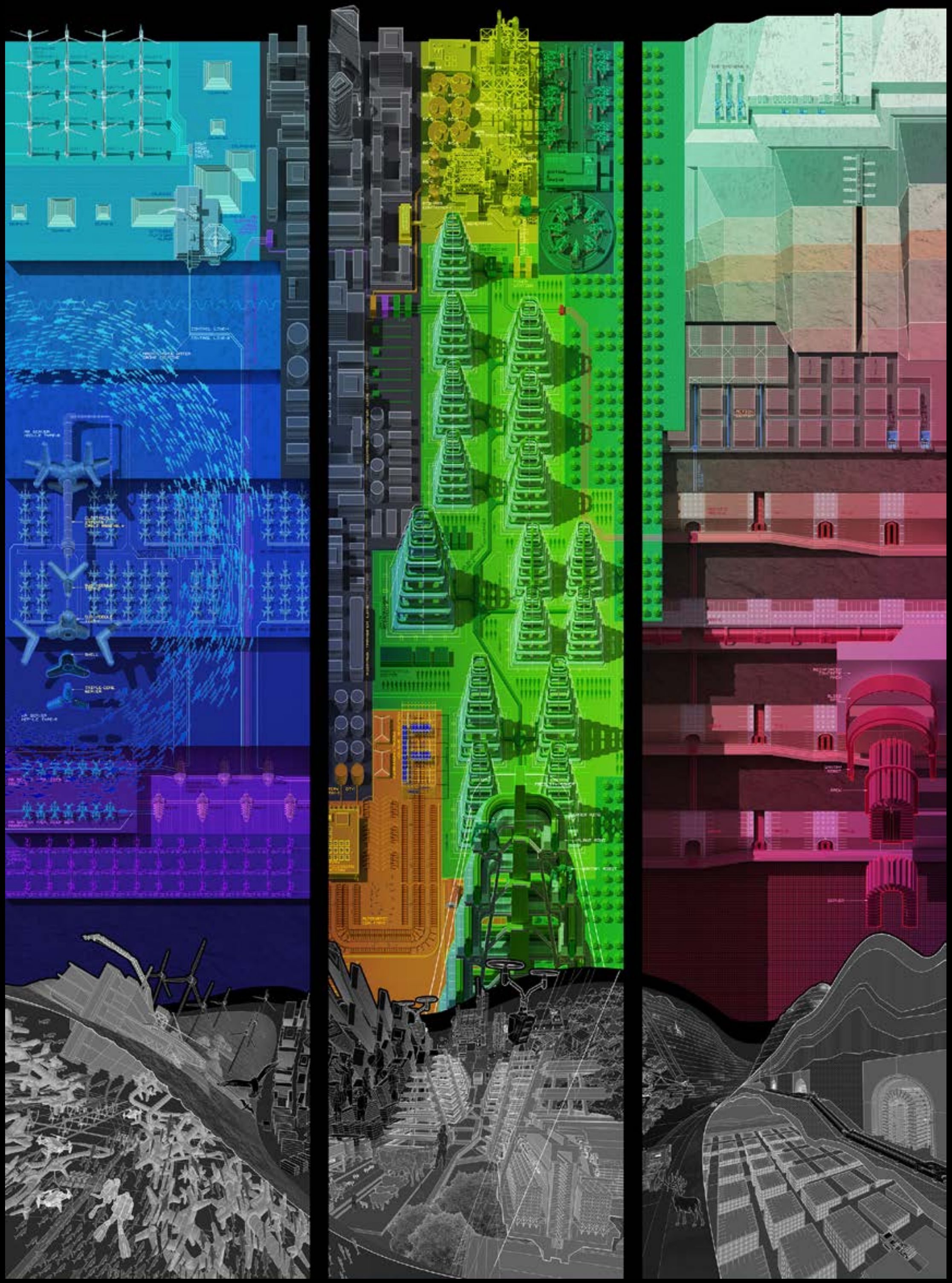
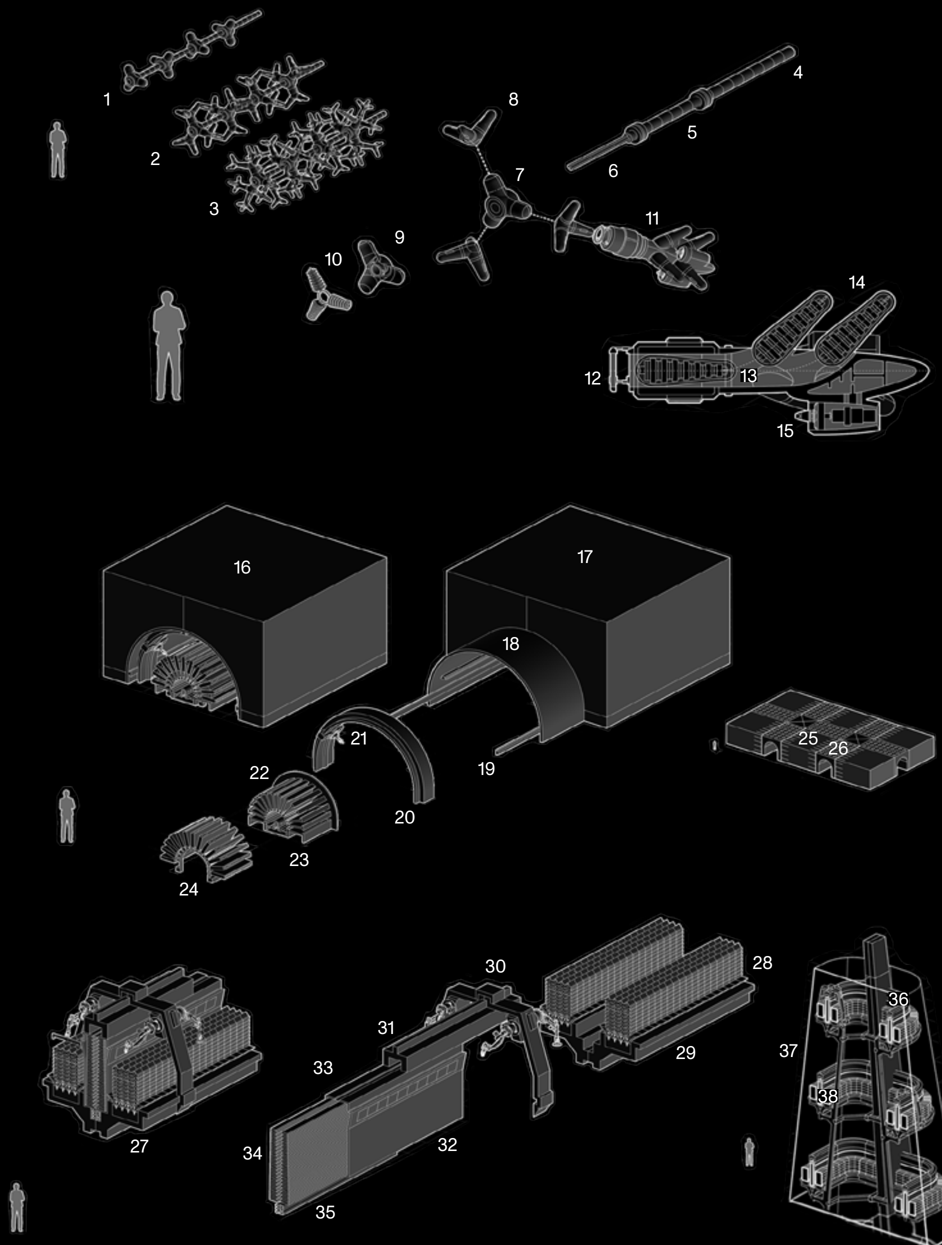


Fig. 5 Three visions for future data centres, integrated into global, natural and industrial systems.



SERVER DESIGN I (Top)
Modular servers are connected in series by cables on different branches which are connected to submarine cables.

1–3 Artificial Reef Server Arrays,
4 Insulating tube
5 Connecting ring
6 Internet cable assembly
7 Sub module, Tier-I
8 Sub module, Tier-II
9 Shell
10 Triple-cone server
11 Water drone
12 Capture port
13 Transport route
14 Server dock
15 Battery and turbine

SERVER DESIGN II (Middle)
A confidential data centre is set up in the reinforced structure of an underground coal mine.

16 Archive's arch
17 Reinforced concrete arch
18 Artificial reef server array, Aggregation-III
19 Slide rail
20 Gantry robot
21 Robot arm
22 Arch rack
23 Cables and hot corridor
24 Servers
25 "Pillar": Remained coal
26 "Room": server

SERVER DESIGN III (Bottom)
The multi-storey greenhouse with servers and crops, taken care by robots which are moving on the slide rails.

27 Greenhouse data array segment
28 Crops
29 Supporting structure
30 Gantry robot
31 Slide rail
32 Server shell
33 Heat outlet
34 Server with cold corridor
35 Electrical and Internet cable
36 Facility tower
37 Crops-server ring
38 Supporting structure
39 Glass curtain

THE URBAN EXCHANGE PLATFORM

Farian Anwar, Callum Birchall

The complex operations of logistics demonstrate the flows and exchanges of capital, resources and information over vast territorial landscapes. Clare Lyster describes the space of logistics as a 'large multi-scalar assemblage, whose territory extends from the planetary (satellites) to the local (a doorstep)'.[1] Logistics; encompassing the boundaries of trade negotiations to the operation of transportation networks, not only allows for the material connectivity of the physical world, but extends to the realm of the digital and immaterial. In this sense, the abstract 'spatiotemporal phenomenon' of logistics, its impact on the Earth and its associated footprints, can coincide with Lyster's understanding of the 'Hyperobject' defined by Timothy Morton. Footprints in the form of barcodes and packaging are indicative fragments of a wider and more complex procedure from which consumers experience a sense of detachment. Moreover, the parallel and closely connected transfers of data and information that correspond to physical objects have allowed large corporations to attain more efficient transfers that reduce friction within the supply chain process. However, the capitalist desires of large corporations have resulted in real world consequences, through the exploitation of labour and natural resources.

The desire for faster and more efficient logistics to accommodate 'same-day' delivery turnarounds, as well as the changing demands of products during peak months and in the case of a global crisis, have highlighted the flaws in the last-mile delivery model. Companies are increasingly spending on transport costs to bridge the distance between distribution centres and their consumers. Moreover, the unsustainable amounts of transport emissions and packaging waste that are produced as an outcome of increasing demands have resulted in the need for more integrated logistics systems that highlight the consequences of our consumption.

Informed by research, The Urban Exchange Platform (UXP) proposes a future for a decentralized logistics model. It envisions the integration of automated distribution modules within a network of shared, reused footprints in the city, demonstrating the flows of data, waste and products. The UXP strives to create a relationship between people, technology and their wider context, capturing the scales of logistical exchanges and encounters. Through the rising interest in autonomous vehicles and flexible work culture, existing buildings such as car parking structures and offices offer potential vacancies in the future. For exchanges to operate sustainably at a local city scale, the UXP aims to utilize this opportunity to reuse footprints for distribution in primely located retail and business districts. Furthermore, the project imagines a system that is woven into the city and the lives of its inhabitants, engaging with public space and the history of the existing urban landscape. This includes a waste management and recycling scheme whereby a circular economy is promoted through the physical exchange of packaging waste for consumer goods. The modular system aims to flexibly manage distribution while balancing the demands of both the environment and society. Through the final visual, the UXP depicts a future of coexistence and productivity, the extremes of which are open to interpretation.

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[1] Clare Louise Lyster, 'Territories of Equivalence: Objects of the Logistical Apparatus', Footprint 23 (Autumn/Winter 2018), 25, https://doi.org/10.7480/footprint.12.2.2100.

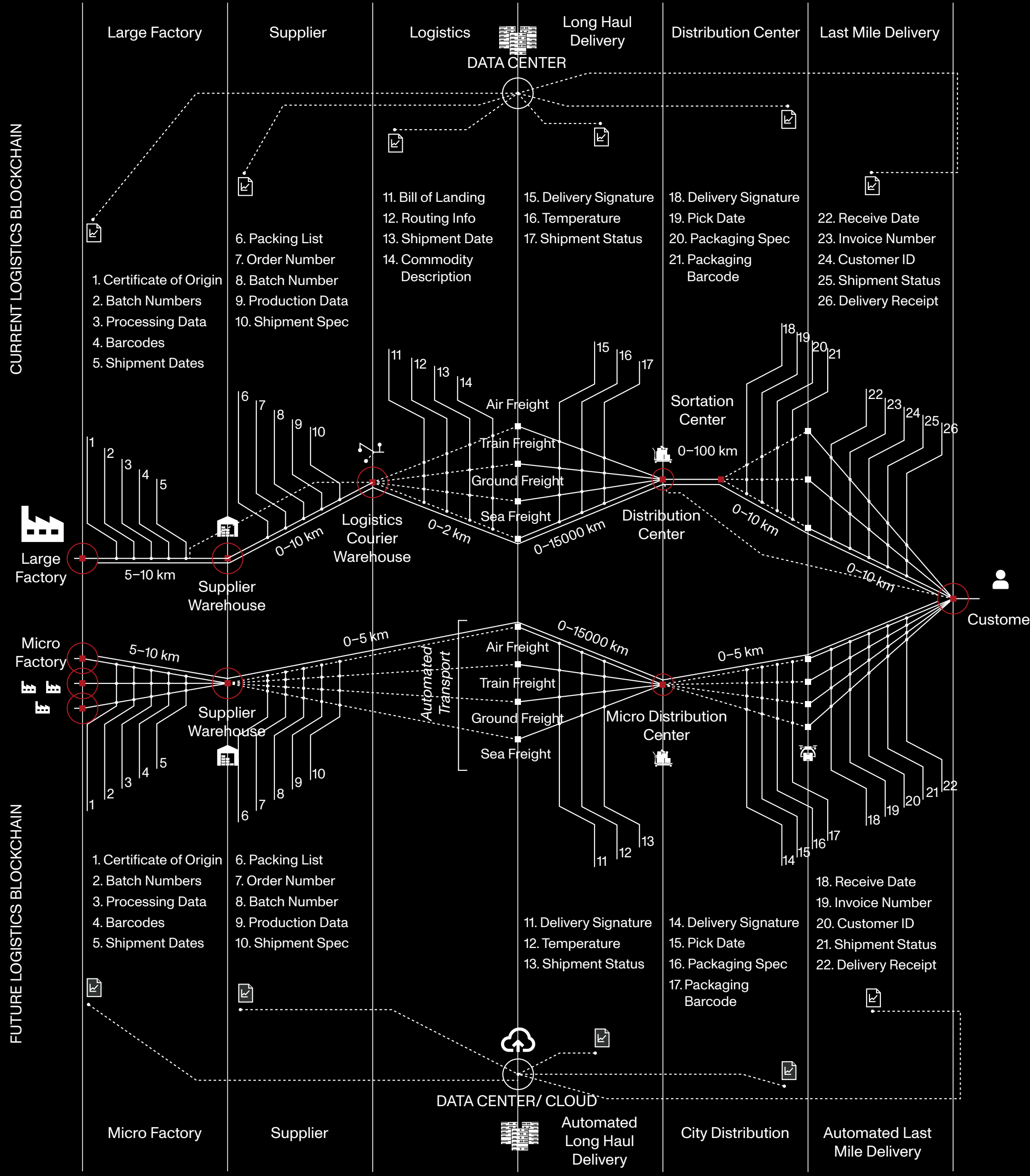


Fig. 1 The systematic relationship between data and the physical infrastructure of logistics and data recording throughout the supply chain process, current and projected future. Source: IRC Group.

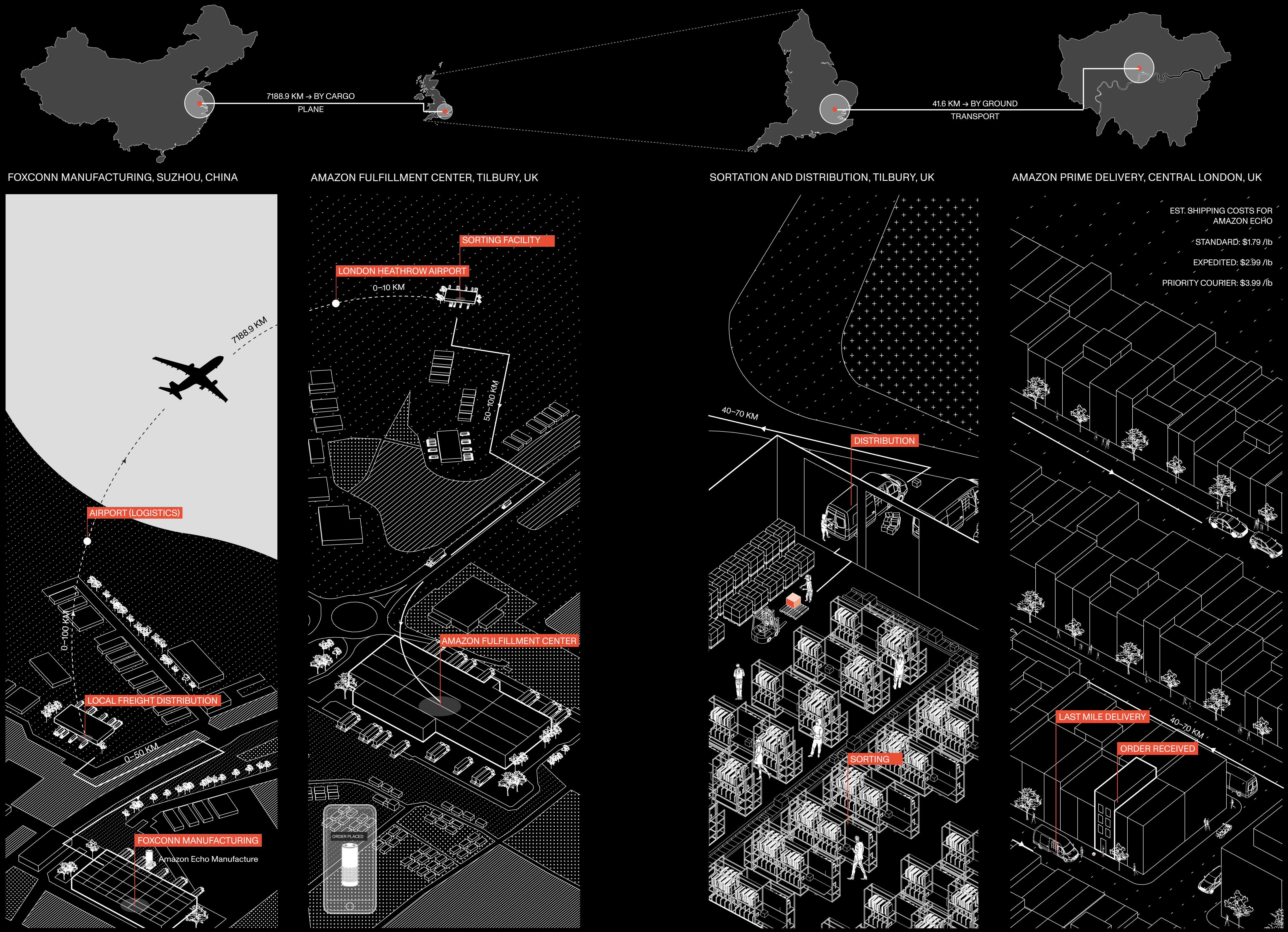
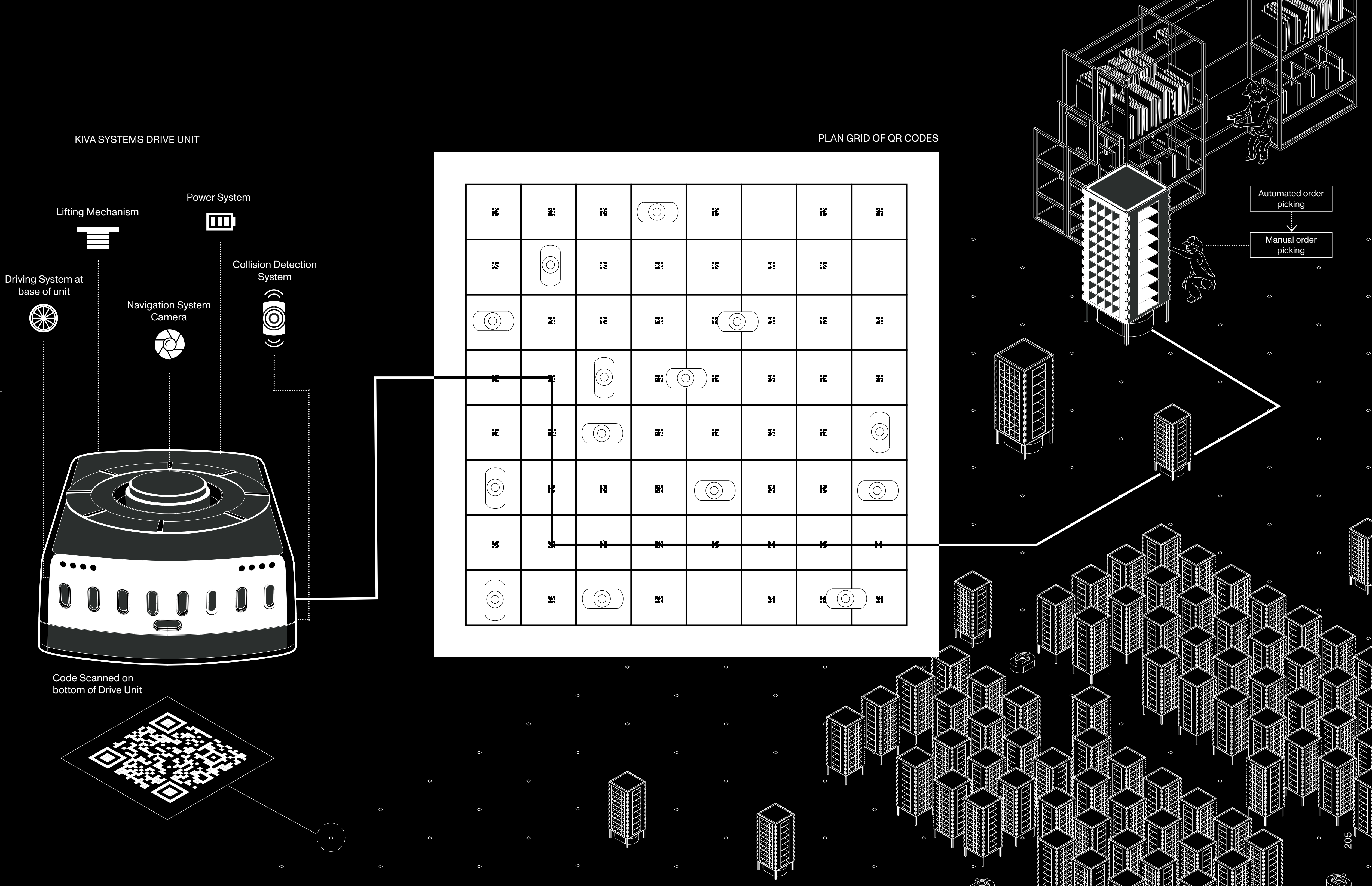


Fig. 2 Amazon Product Journey to UK. Supply Chain overview of Amazon's product journey—cost and distance travelled for the delivery of an Amazon Echo.

‘This company built one of the world’s most efficient warehouses by embracing chaos.’ Sarah Kessler

Fig. 3 Distribution Centre Order Picking: Amazon Kiva Robots.

Camera sensors at the base of the programmed KIVA robots allow them to follow QR codes that are arranged on the floor grid. This enables them to move goods horizontally to the human pickers, who collect and pack the products for distribution.



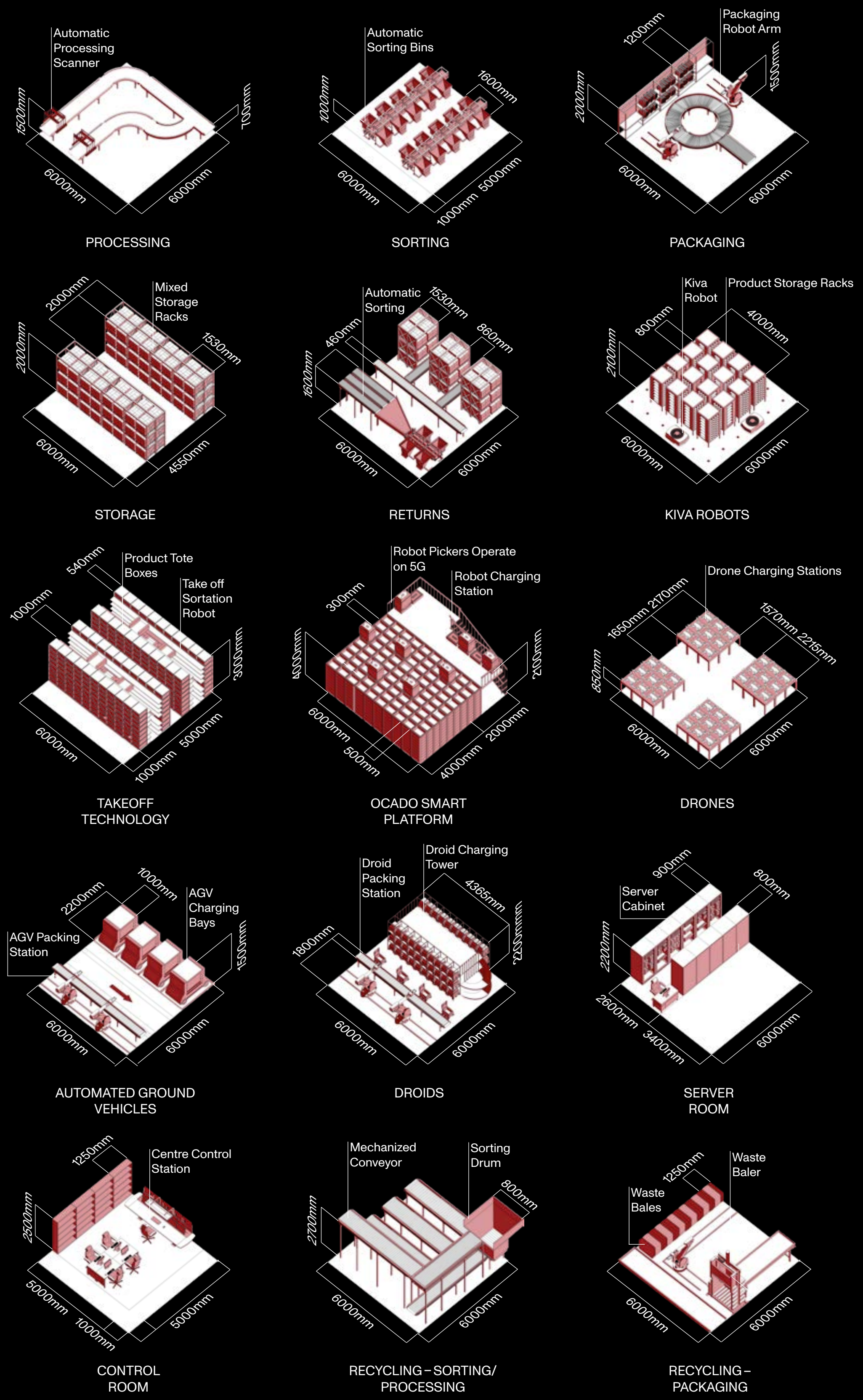


Fig. 4 ↑ The Urban Exchange Platform.
Fig. 5 → Programme Modules.

FROM THE GRAVE TO THE CRADLE

Federica Longoni, Filip Romanuik

What kind of data do we get from space, and what is the infrastructure behind it?

Fifty years ago we had images of outer space, but what we did not have were images of Earth seen from space. NASA released the first such picture, taken by a satellite, in 1966, but it only captured part of the planet. A photograph of the whole Earth was taken in 1972: later named The Blue Marble, it constitutes one of the most valuable successes in space exploration. One astronaut who was on the mission said: 'When we originally went to the moon, our total focus was on the moon: we weren't thinking about looking back at the earth. But now that we've done it, that may well have been the most important reason we went.' [1]

The Whole Earth image started an important reflection regarding our impact on the planet, raising awareness of its fragility: from outer space, Earth could be seen for the first time as a sphere, an enclosed environment with limited resources in comparison with the infinite availability we were used to thinking of. Since the launch of the first satellites, Earth suddenly became a 'planet', a 'satellite in itself'. [2]

Nowadays, satellites are responsible for collecting data for monitoring the environment, giving us an objective and distant picture of our impact on Earth.

Until recently, however, we did not realize that the process of satellite launching was causing a significant amount of debris in space and CO2 emissions in the atmosphere: when satellites reach the end of their lifespan they are either sent into a graveyard orbit, burned in the atmosphere or sent back to Earth to a dedicated point in the Pacific Ocean: the Nemo point, the farthest point on Earth from the human race.

Since the space age started, we have enlarged our footprint to the whole cosmos, moving from the condition of the Anthropocene to the one of Anthropocosmos. While aware of our impact on Mother Earth, we did not realize we were just redistributing our mode of consumption to space. Can we make the whole process of obtaining data from space sustainable?

The project aims to envision a post-Anthropocosmos condition of satellite launching interested by a zero-waste total approach from energy to materials, from the ground to the space.

A solar panel plant positioned in outer space is the main source of energy, which is transmitted to the rocket through microwaves. The same energy from space is also used to divide water into its primary components through electrolysis, creating the fuel used by the rocket: liquid hydrogen.

Satellite debris at the bottom of the oceans is recovered and divided into its main materials, which constitute valuable resources at risk of depletion on Earth. Likewise, satellite debris in space is reassembled and made functional again in recycling stations.

The whole project is positioned in the Nemo point, transforming what was a spacecraft graveyard into the cradle of a new sustainable system.

> “One’s garbage doesn’t go ‘away’ it just goes somewhere else”
>
> TIMOTHY MORTON

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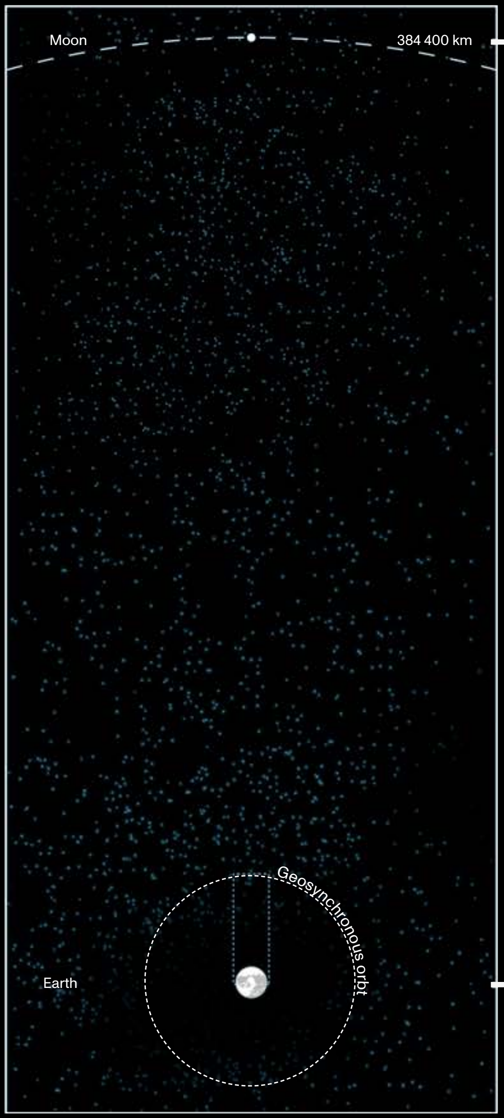
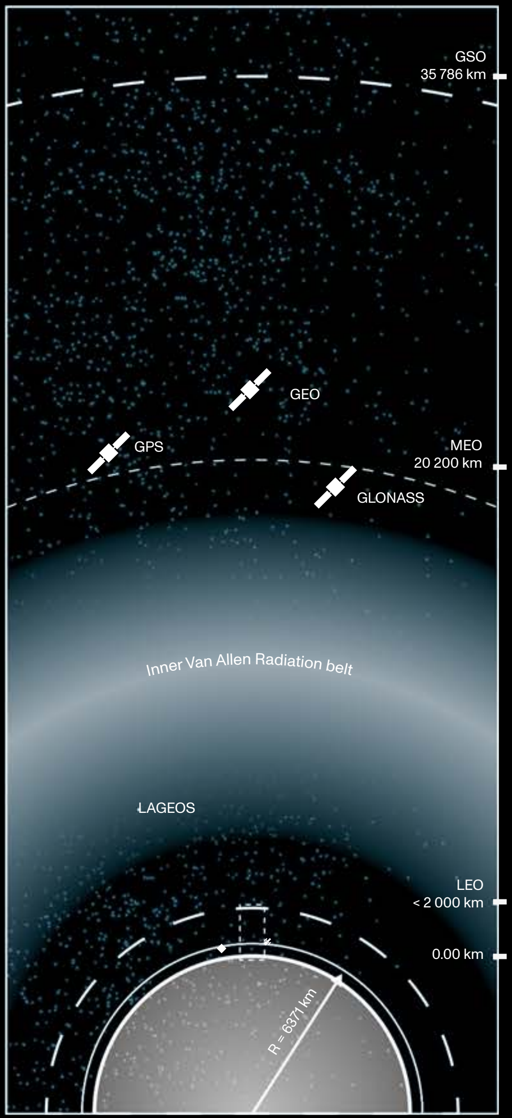
[1] David Beaver, OVERVIEW from Planetary Collective on Vimeo.

[2] Eric McLuhan and Frank Zingrone, Essential McLuhan (London: Routledge, 1997).

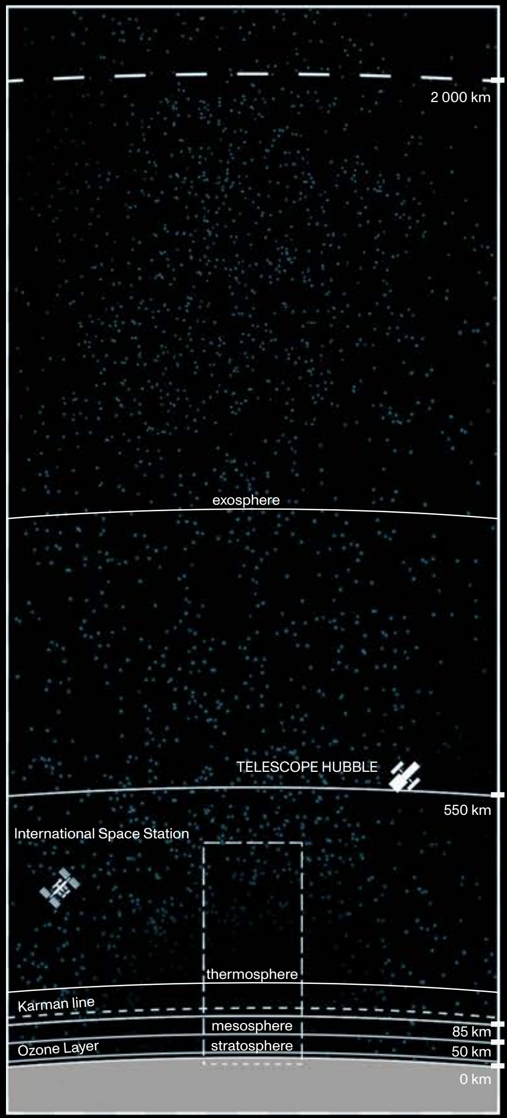


SCALE 1: 3 000 000 000



SCALE 1: 300 000 000

Fig. 2a The planet Earth in relation to its biggest natural satellite: the Moon.
Fig. 2b Section through planet Earth with its three primary types of orbits, Geostationary, Medium, and Low Earth Orbit.



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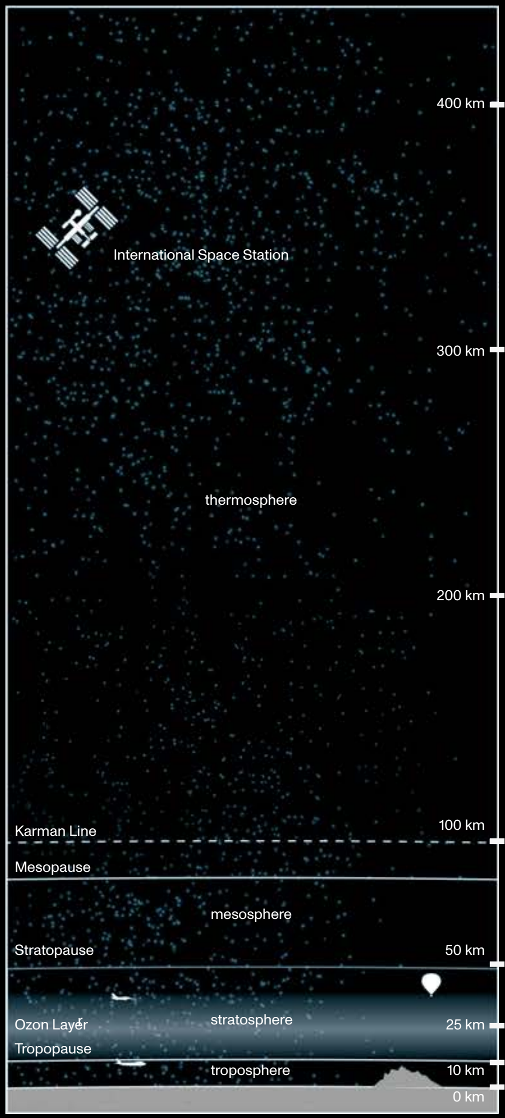
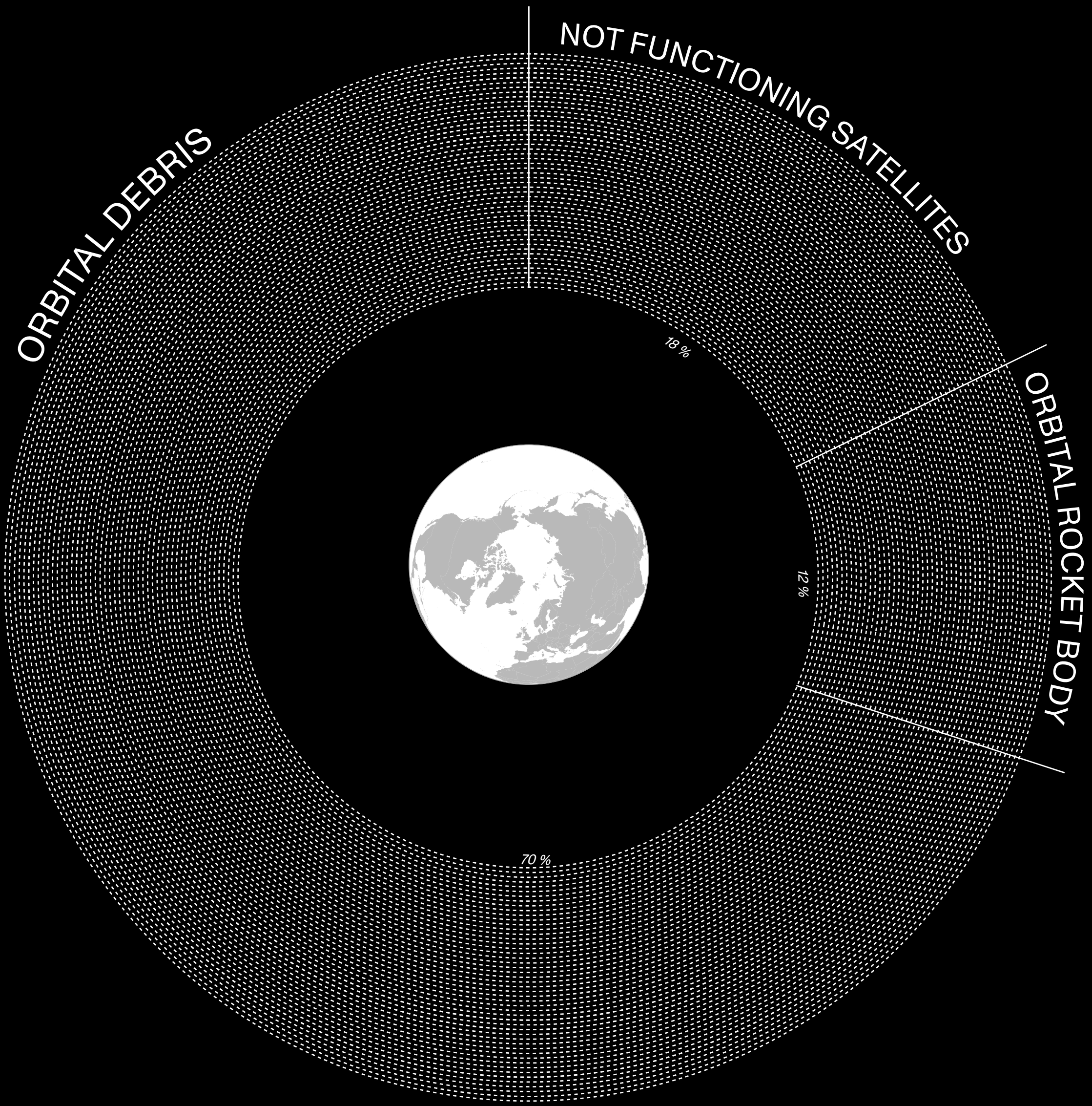


SCALE 1: 3 000 000

Fig. 2c Sections through the Earth's exosphere where most of the space telescopes, bio satellites, satellite internet constellation and other small satellites are located.
Fig. 2d Planet Earth's atmosphere with its ozone layer. Kármán line at 100 km altitude is considered to be the border of the Outerspace.



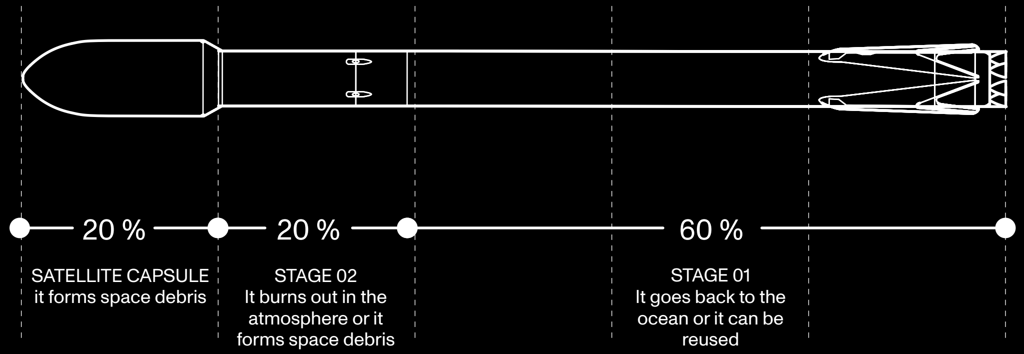


Fig. 3 ↑↑ Percentages of active and inactive satellites. Data Source: ESA's Space Debris Office—Space debris by the numbers.
Fig. 4 ↑ Rocket overview: the satellites constitute only a small piece of a much bigger entity: the rocket. The majority of its components are displaced in either space or down to Earth forming a relevant quantity of debris.

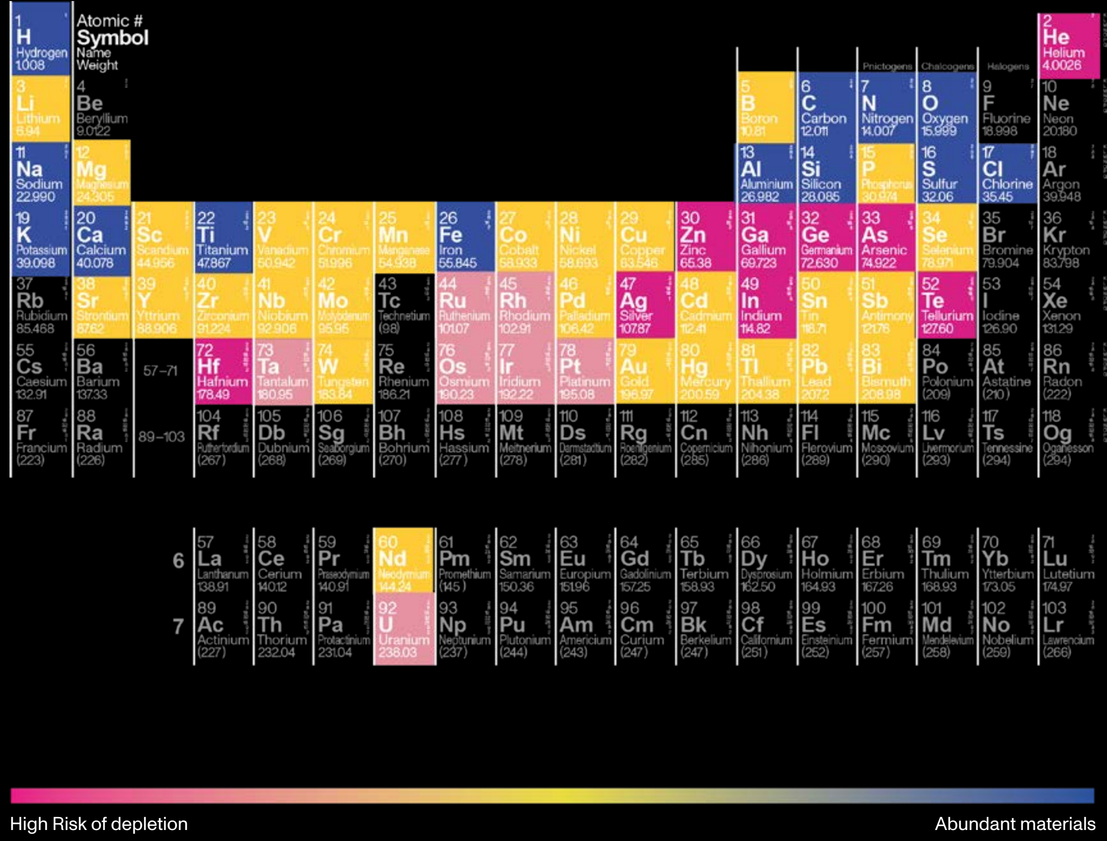
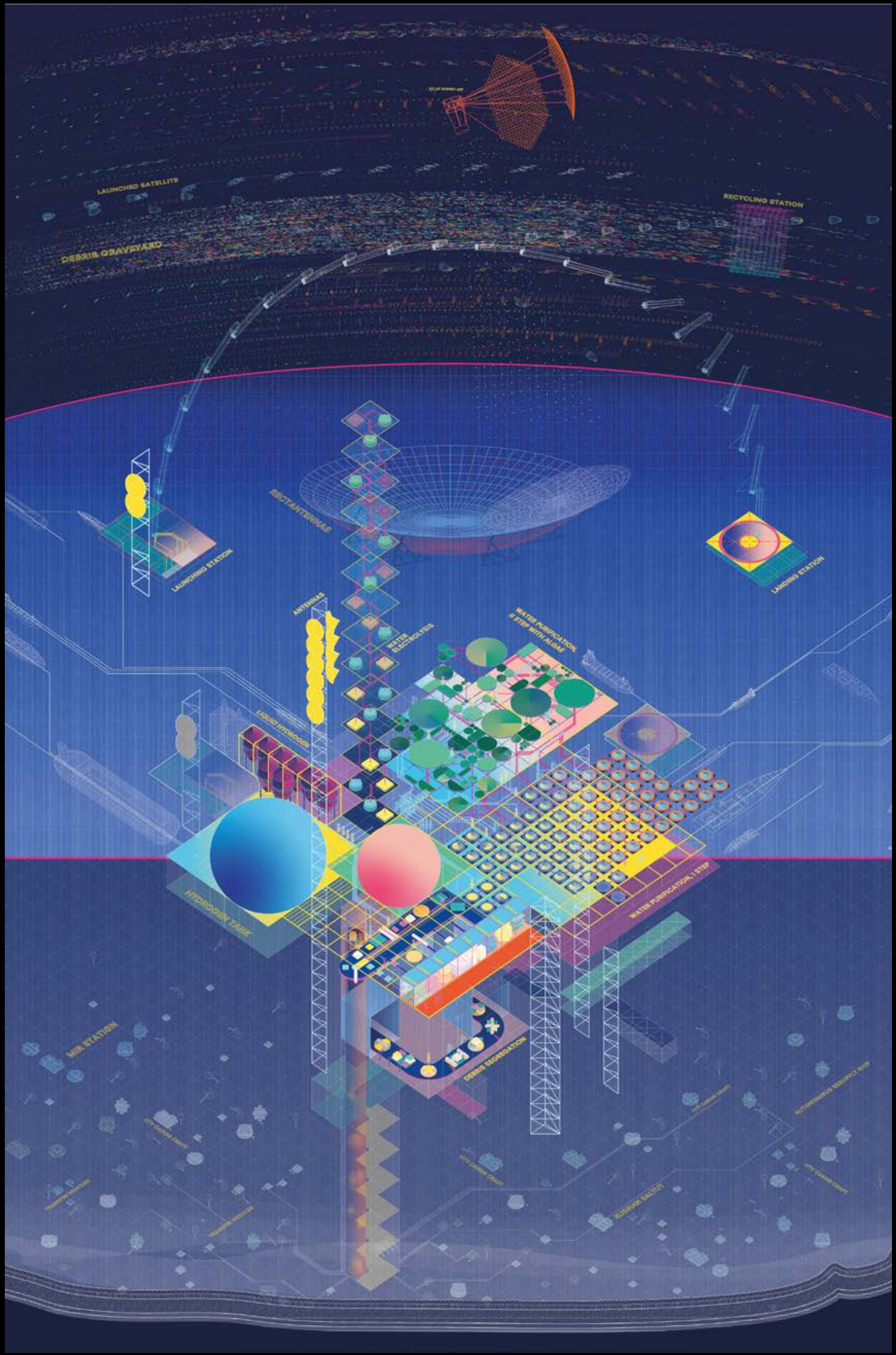


Fig. 5 Endangered elements periodic Table—Graphic Reinterpretetion by the authors. Source: Endangered elements periodic table by Mike Pitts, Director of Sustainability at Chemistry Innovation, UK. This version of the Periodic Table provides an assessment of the elements that will be in short supply and endangered over the next 100 years. The majority of the materials used in the construction of satellites are falling within the range of limited resources.



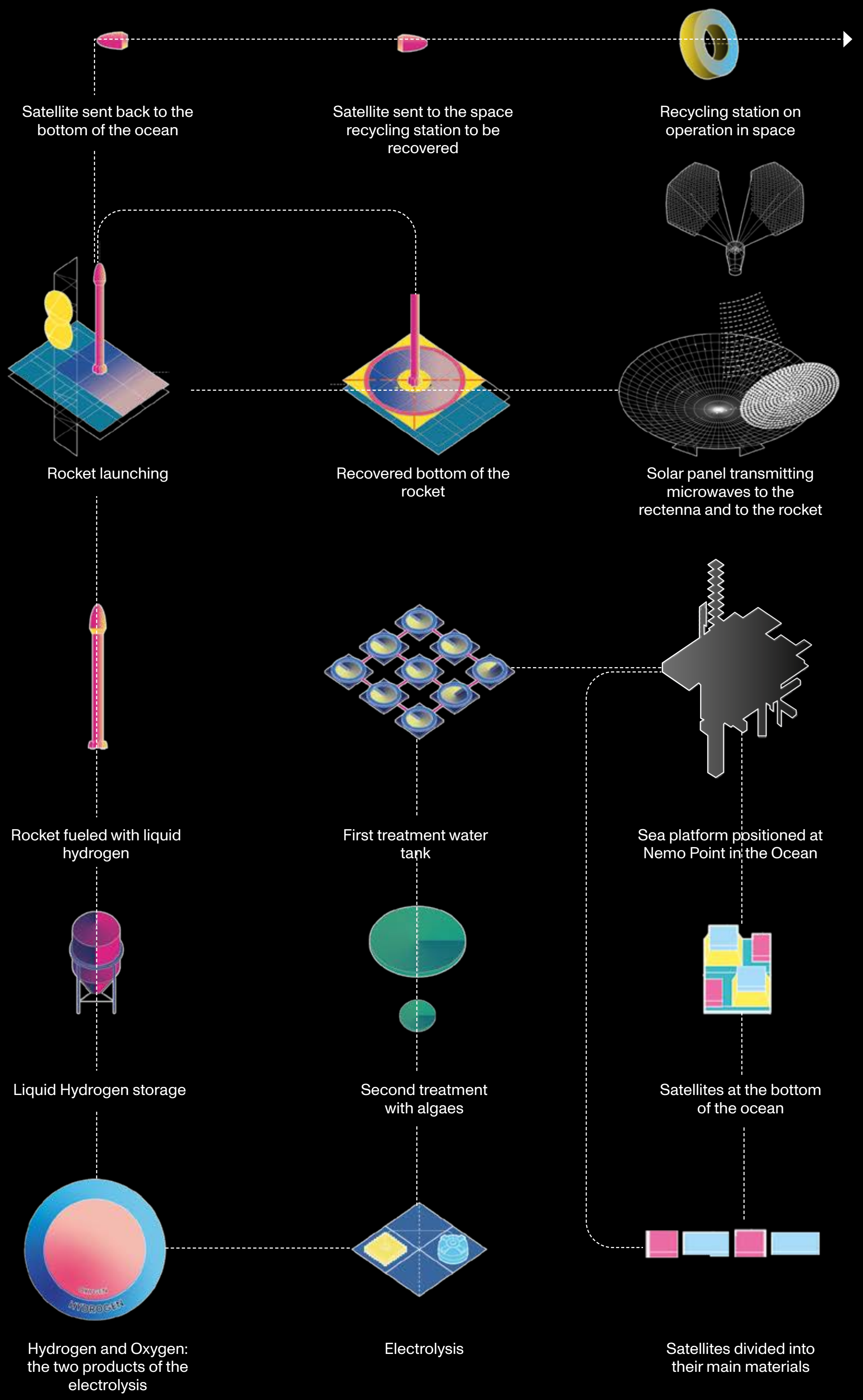


Fig. 6 System diagram showing the relations between designed elements across the Ocean, the Earth and Outer Space.

CON(TRO)VERSING WITH MARS

Emma Chris Avrămiea, Martah Lundheim

Artificial objects in space are losing their purpose, either because they are breaking down or becoming redundant. In our quest for knowledge, fame and natural resources, we are leaving behind a trail of man-made objects, abandoning them when they are no longer useful. Instead of an obsession with the new, and a discarding of the old, patterns characterizing our capitalist society, what if we could extend a circular ecology to the energy-intensive endeavour of space research?

While space exploration is marketed as a global effort, statistics reveal a claim to space that is restricted to a selected few actors with the necessary knowledge, funds and infrastructure to explore space. Access to space relies on collaborating, and being allowed to collaborate, with the main players of the field. Thus, space exploration closely mirrors the present geopolitical climate on Earth.

Our position is to not strictly regulate and limit our knowledge of the universe, nor to limit the use of infrastructure to one or a couple of Space Agencies. On the contrary, we believe in extending our knowledge of space, while at the same time building a more sustainable infrastructure. Our proposed communication hub is a robotically operated base in space, orbiting around the planet Mars. Its main tasks are retrofitting and maintaining existing satellites, increasing the amount of data transferred between Mars and Earth, and managing an increasingly complex network of artificial celestial bodies.

In the short term, the hub will facilitate a fully robotic exploration of space. In this scenario, our position is that a human-focused mission on the surface of another planet would be too risky and counterproductive as of now. Current knowledge of the behaviour of the human body in space is insufficient to ensure a safe manned Mars mission. Furthermore, a human would contaminate the planet with trillions of Earth microorganisms. If these organisms were to infect the surface of Mars, it would be impossible to tell if Mars ever supported life on its own, and future scientific efforts would be hampered. When space research has reached a definitive conclusion in regard to life on Mars, and safe technology has been invented, we could re-evaluate using the hub to also support a human settlement.

The ISS has proven that a structure in space can be operated through shared consent and separately owned modules. However, the ISS is owned and shared by major space companies, with little room for recently established parties. An important challenge would be to ensure that governing power lies with the users of the hub, and that new actors are protected by a more neutral, scientifically focused support. To protect and enable new actors' access to space, it is likely that a new legal system, and a new infrastructure system, will be required to democratize space. The hub will enable the latter, and then it is up to the Earth's inhabitants to enable the former.

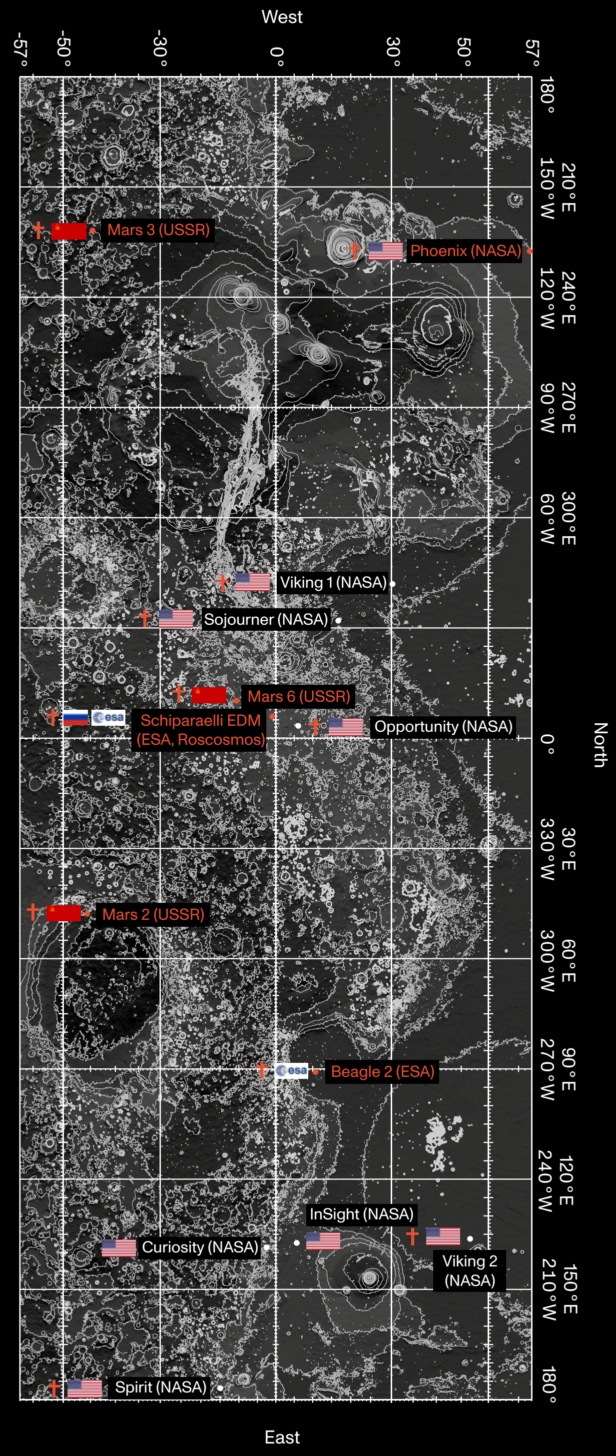


Fig. 1 Objects on the surface of Mars. Source: Interior, Geological Survey, Reston, VA (2003).

Fig. 2 Missions to Mars.

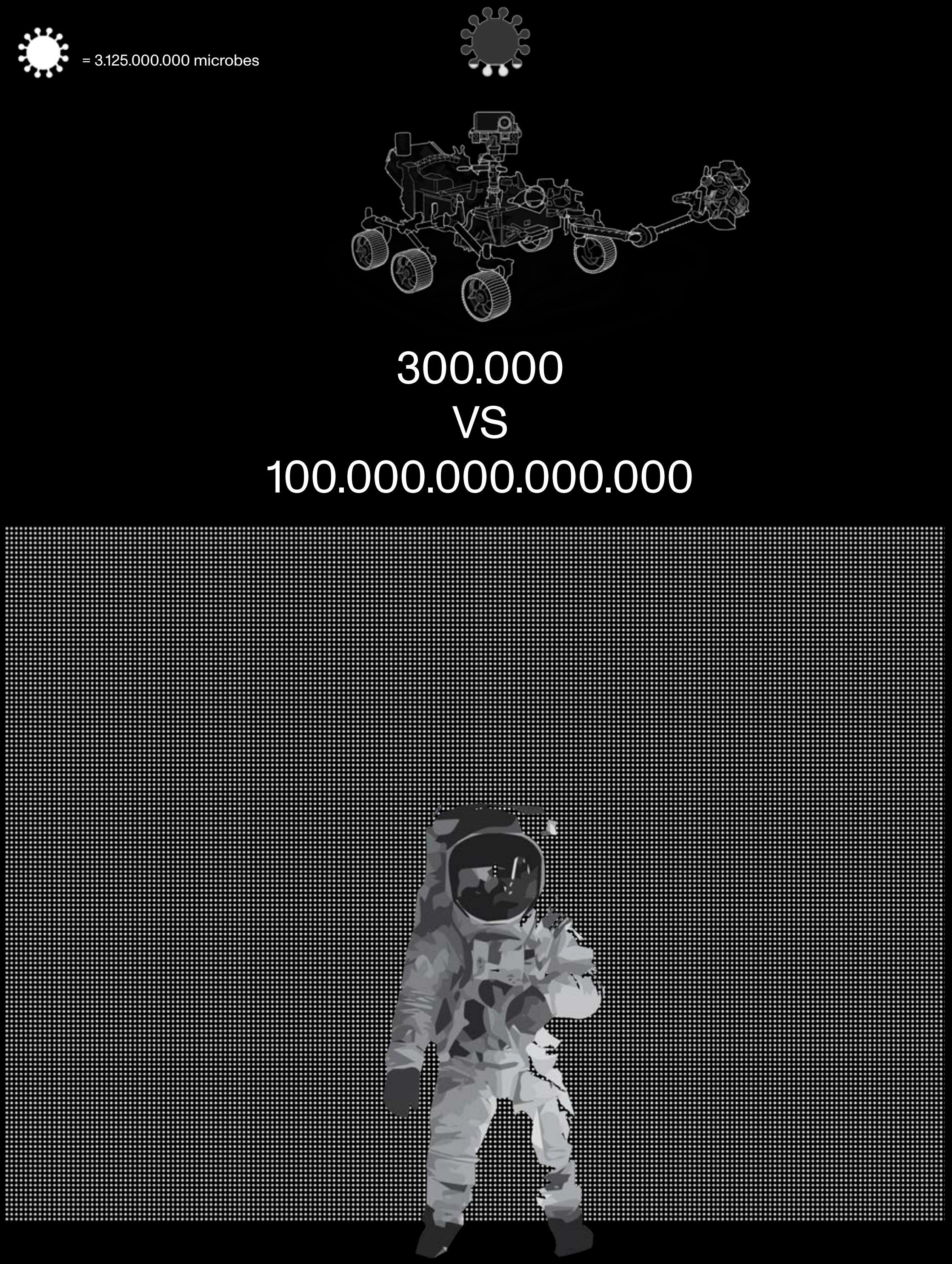


Fig. 3 Amount of microbes contained in a Mars exploration rover vs a human's.

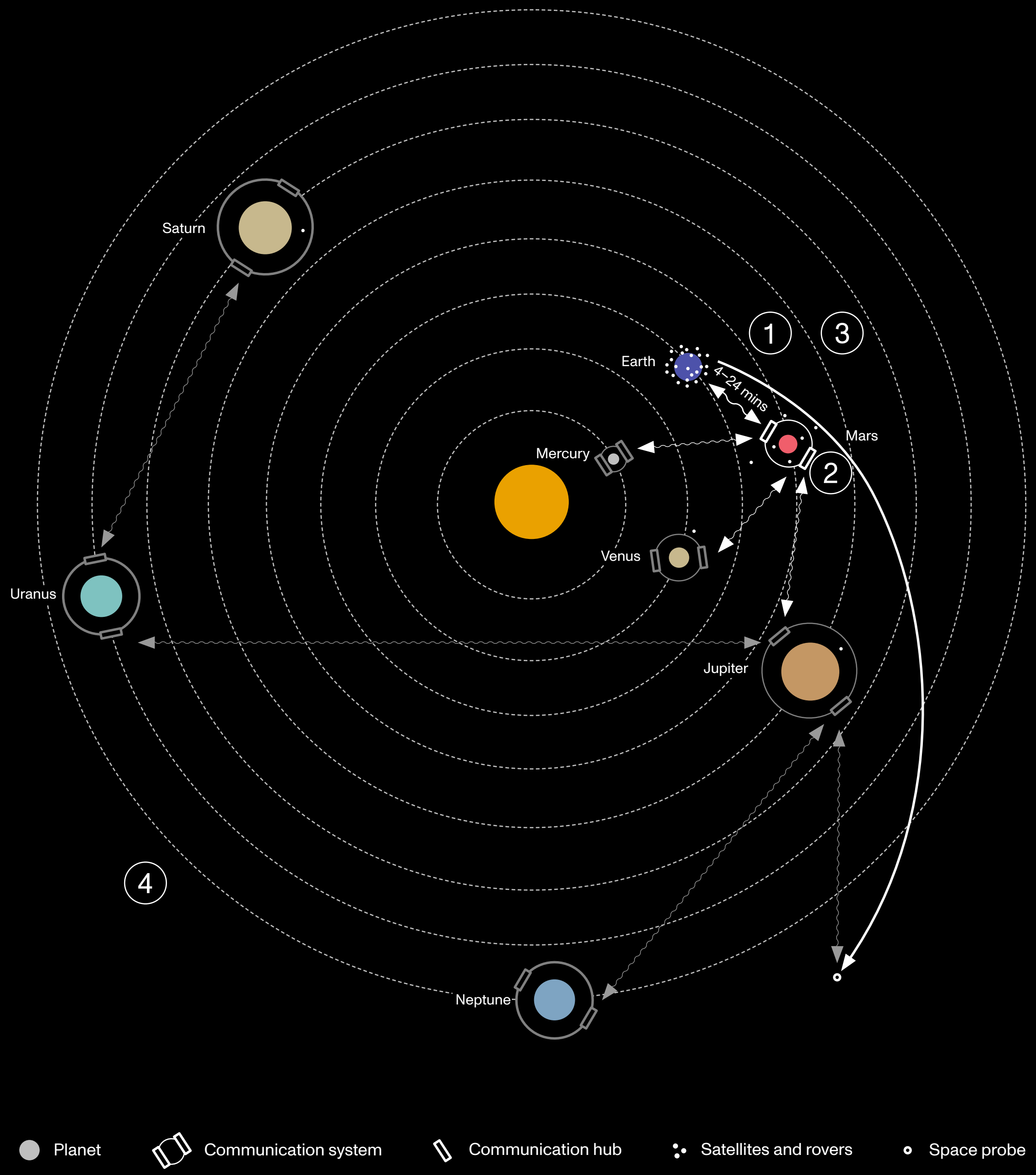
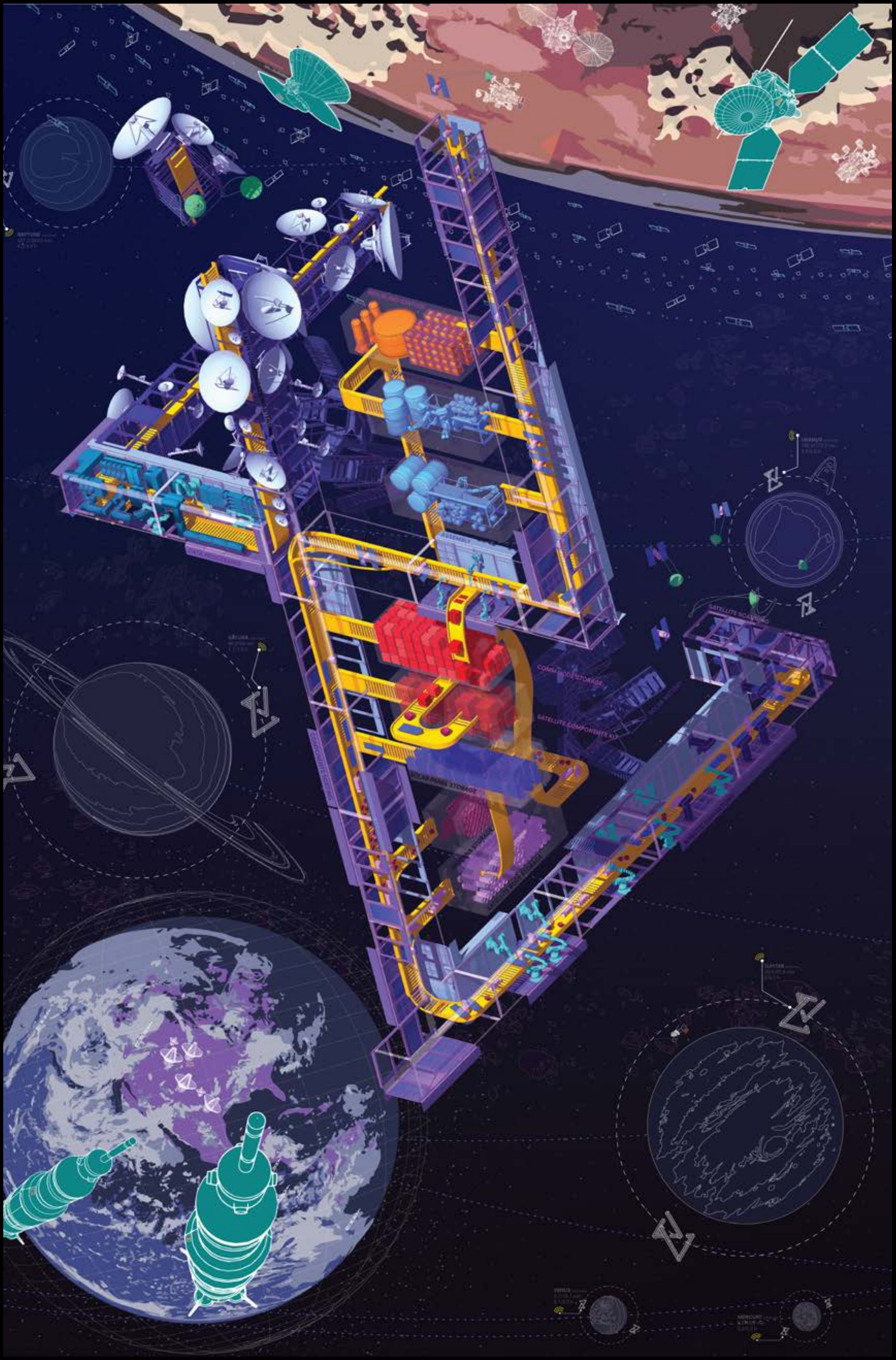


Fig. 4 Links of an interplanetary internet :

1 Most communication from and to Earth is sent via satellites to various strategic locations with powerful parabolic antennas.
2 Infrastructure is established on Mars to create the Martian internet. It is connected with Earth through a communication hub, similar to how the transatlantic cable connects the continents on Earth.
3 Mars is an important relay point and transfers data from other planets in the solar system as well as from its own planet.
4 As human expands further through the solar system the communication network is expanded to the other planets and it will be connected through a series of relay points to reach Earth. All interplanetary communication is done through optical laser.



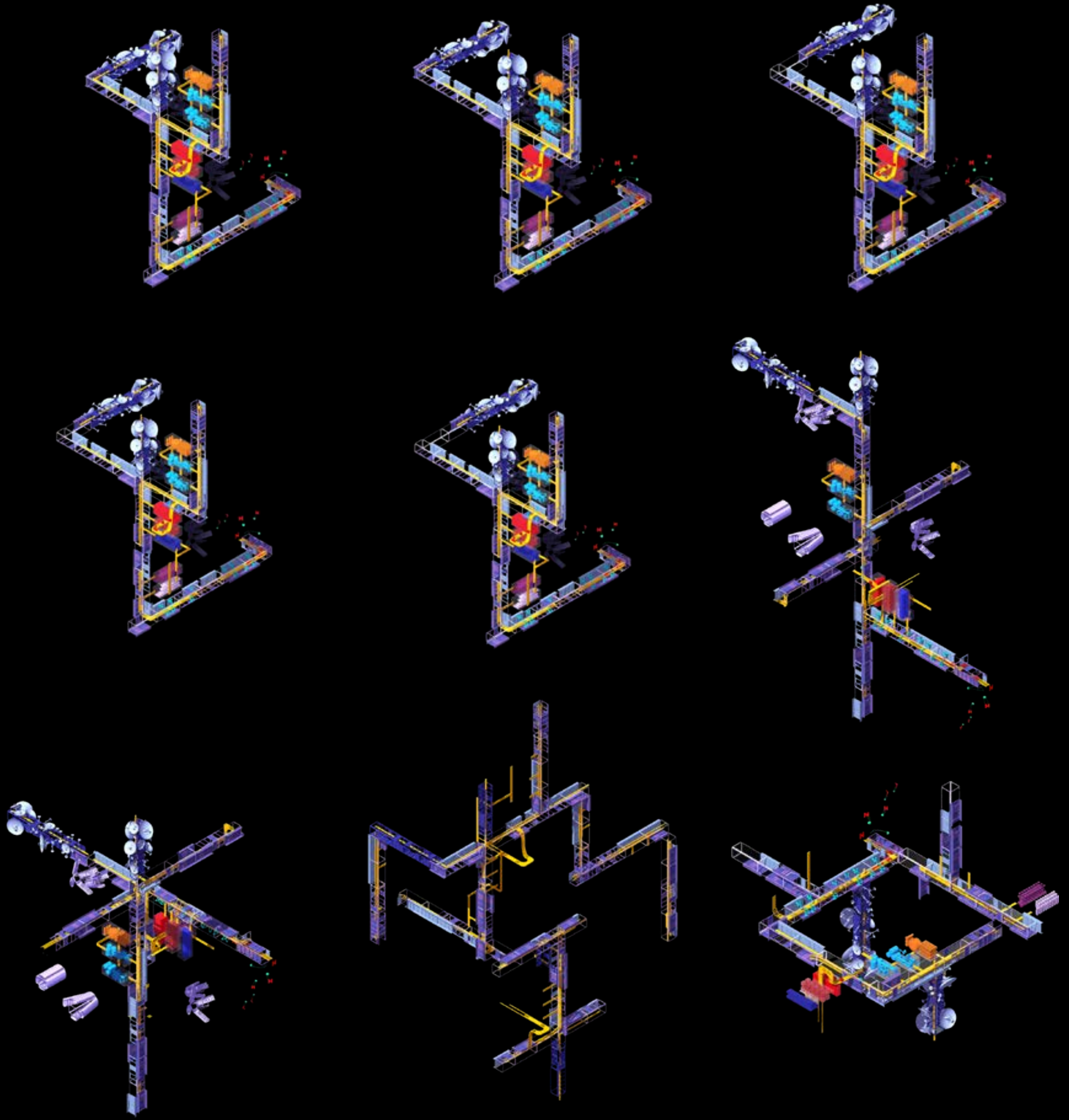


Fig. 5 A modular hub: Enabling communication across the Milky Way. The hub is constructed from identical modules that can be reconfigured to suit the communication or satellite refurbishment activities.

HUMAN DRIVEN HEALTHCARE NET

Sandra Baggerman, Marina Bonet

Over time, humankind has become increasingly dependent on modern healthcare and medicine. In its development, the idea of healthcare has become more and more institutionalized and entangled with modern technology, while the notion of care has changed course and meaning.

As the definition of care evolved, so did the definition of what a ‘patient’ is. One of the early providers of healthcare was the church. Due to a lack of medical knowledge, ‘giving care’ was defined as giving the grace of God and forgiveness. Mental care was the focus rather than providing a physical cure or remorse. From 1700 on, clinical knowledge increased and evolved because of studies and autopsies. The body was seen as a study object. From the middle of the nineteenth century, technology evolved and with it clinical healthcare. Curing the body was now looked at from a purely clinical point of view. The body was seen as a machine that, like a car, could be fixed by tuning it and adjusting its settings. Care therefore transitioned into the treatment of illnesses. Throughout the twentieth century, clinical knowledge evolved, and the patient was seen more and more as a machine. Healthcare in the twenty-first century is characterized by the heavy use of technology. This has led to the objectification of the body, as the patient is part of a factory-like healthcare system. At the same time, people are focusing more and more on their health—they perceive their body as a temple, but the healthcare system still functions like an inhumane factory.

The human body has been dehumanized by the system and is seen as a device that can be fixed with the proper intervention. Healthcare no longer targets healing, but instead promotes procedures that exhaust the body extensively, ultimately leading to a higher and higher consumption of health care. The expropriation of healthcare thus maintains a self-sustaining system where the emphasis lies on the institution and its treatment, rather than on providing the patient with sustainable care and good health. Humankind is becoming increasingly dependent on the consumption of modern medicine.

To break free from this nemesis, we need to regain autonomy and responsibility for our bodies. We need to reconsider the architecture of the healthcare system by placing the patient at the centre of care.

Implementation of healthcare 4.0, the gathering of body performance data and the incorporation of wearables can offer a certain level of autonomy. The suggested vision assembles a non-linear relationship between various parts of the organization of healthcare, including different flows and diverse operational parts, insurance companies, waste production, energy consumption and other factors.

Putting the patients at the centre of care and the implementation of healthcare 4.0 form the base of the future’s decentralized healthcare typology, where the modern non-normative patient receives tailor-made care. A flexible, efficient and sustainable architecture is the result of the thorough implementation of technology and data across all levels of the system.

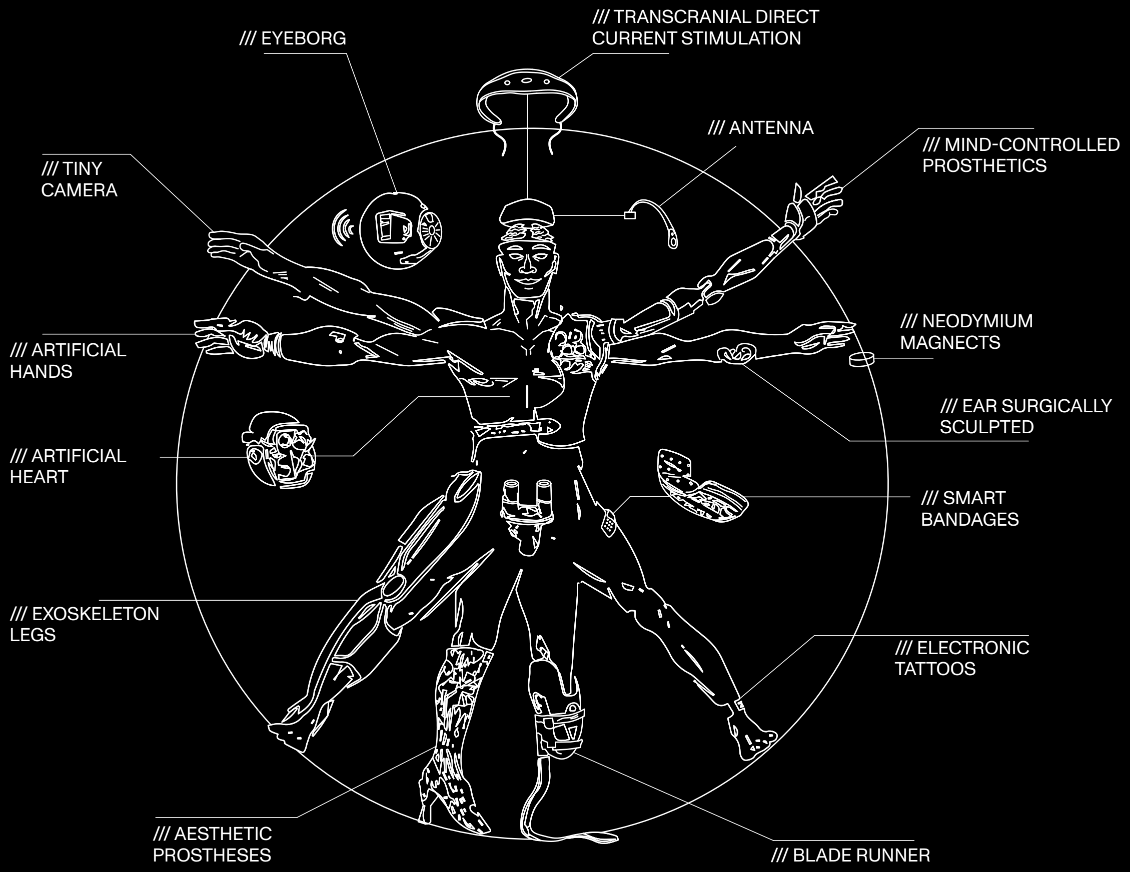
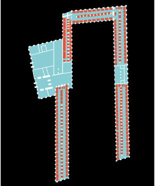
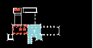
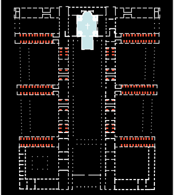
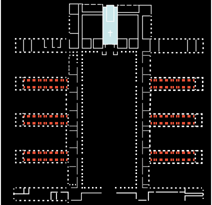
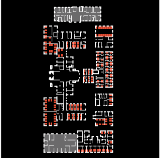
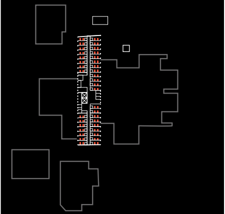


Fig. 1 Future human cyborg. Drawing by Jeremy Li Ho Kong and Alice Chau Ka Yee.

	HOTEL – DIEU PARIS, FR (650)	GREAT HOSPITAL NORWICH, UK (1249)	HOTEL – DIEU PARIS, FR (1787)	HÔPITAL LARIBOISIERE PARIS, FR (1850)	MT. SINAI HOSPITAL NEW YORK, USA (1904)	MODBURRY HOSPITAL MODBURRY, AUS (1990)
TYPE	*"INN OF GOD"*	*CLOISTER TYPE*	*SYMMETRIC 'GREEK CROSS' PLAN*	*PAVILION TYPE 'NIGHTINGALE GALE' PRINCIPLE*	*MONOBLOCK 'STACKED PAVILION' TYPE*	*MEGA HOSPITAL 'DEEP PLAN'*
PLAN	*church* *ward* *research* *support functions*  *5 levels*	 *2 levels*	 *4 levels*	 *6 levels*	 *5 levels*	 *6 levels*
PROGRAM	15%	40%	20%	24%	44%	40%
FUNCTIONS	• grace of God • for sick/dying • take the disease from the street	• grace of God • for sick/dying • give shelter to travelers	• clinical education • cure the sick	• clinical education • cure the sick • research space	• clinical education • cure the sick • research space • institution • nursing school	• cure the sick • private health care
SERVICE	† 🍴	† 🍴 🍃	✚ † 🍴 🍃 ⚯	💧 † 🍴 🍃 ⚯ ✚	🍴 💊 💧 ✚ ⚯	✚ 💧 🍴 💊 👜 ⚗
TECHNICAL INNOVATION	• grace of God • for sick/dying • take the disease from the street	• grace of God • for sick/dying • give shelter to travelers	• gass pipes • oil lamps	• washing facilities • sewage • surgery spaces • germless ventilation • modern heating	• elevator • mechanical ventilation	• air conditioning • artificial light • electric bed • central sterile supply • automatic X-ray • auto analyzers in lab • plastic blood bags • identification bracelets • pneumatic tube system • power plants

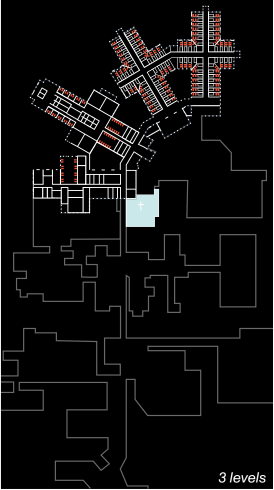
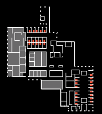
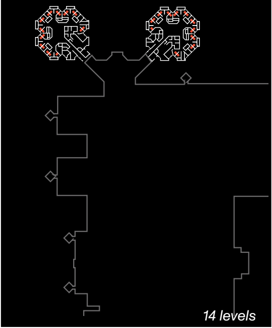
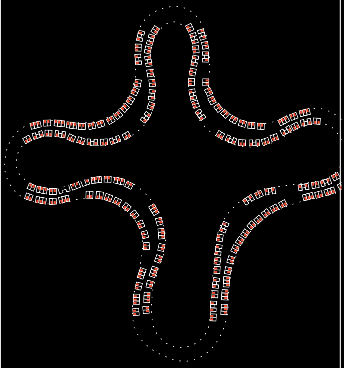
	ST. MARY'S HOSPITAL ISLE OF WIGHT, UK (1991)	CEDARS-SINAI CENTRE LOS ANGELES, USA (1988)	DARTMOUTH-HITCHCOCK MED. C. LEBANON, USA (1990)	NEW NORTH ZEALAND HOSPITAL COPENHAGEN, DK (2014)
TYPE	*MEGA HOSPITAL 'TECH DRIVEN'*	*STATE OF THE ARTS HOSPITAL 'TECHNO-UTOPIA'*	*STATE OF THE ARTS HOSPITAL 'MALL-LIKE'*	*STATE OF THE ARTS HOSPITAL " SUSTAINABLE "*
PLAN	 *3 levels*	 *2 levels*	 *14 levels*	 *4 levels*
PROGRAM	9%	5%	2%	20%
FUNCTIONS	• cure the sick • specialist departments • research space • institution	• patient-centred • specialist departments • research space • shared family space	• short stay hospitalization • health check-up • cure the sick • research space • flagship teaching facility	• patient-centred • place for healing • mental health focused
SERVICE	✚ 💧 ⚯ 🍴 💊 👜 ⚗	✚ 🍴 💊 🧠	🍴 💊 👜 ⚗ ✚ 💧 🤝 ⚯	🍴 💊 👜 ⚗ 🍃 ✚ 💧 🤝 ⚯
TECHNICAL INNOVATION	• focus on low energy consumption • electronic medical records • computers enter the work floor • MPI (master patient index)	• automated mechanical tools • blood and cell separator • balloon catheter • smart infusion pump • safety needles	• radiosurgery • first bionic limbs • pill shaped camera • personal glucose meter • automated external defibrillator	• medical lasers • vascular closure devices • robotic radiosurgery system • mechanical seal and puncture devices • organ transporters • oxy mask • 3D printed organs

Fig. 2 The architecture of healthcare.

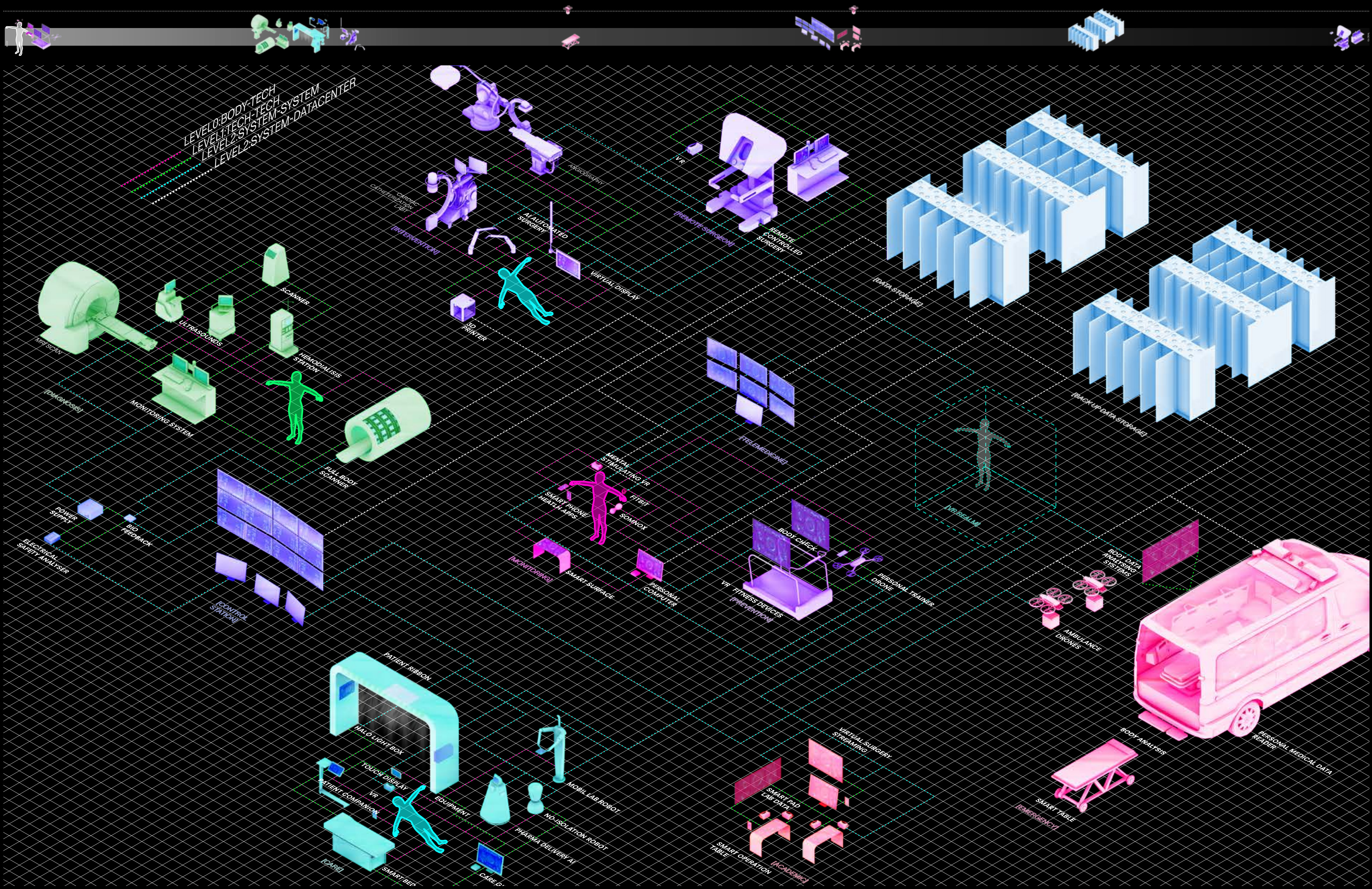


Fig. 3 De-centralized person-focused healthcare system.

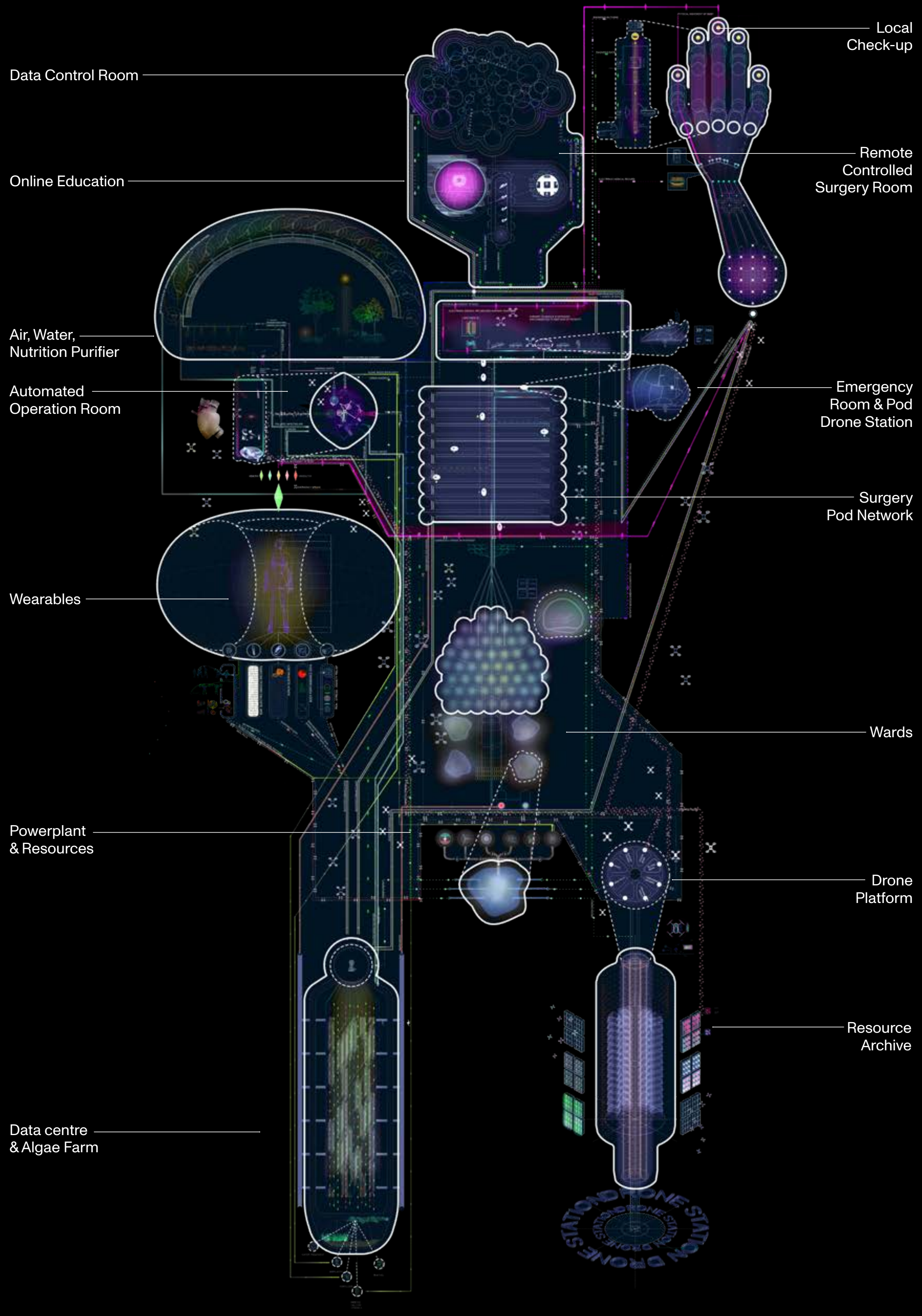


Fig. 4 The future architecture of health care by Sandra Baggerman.

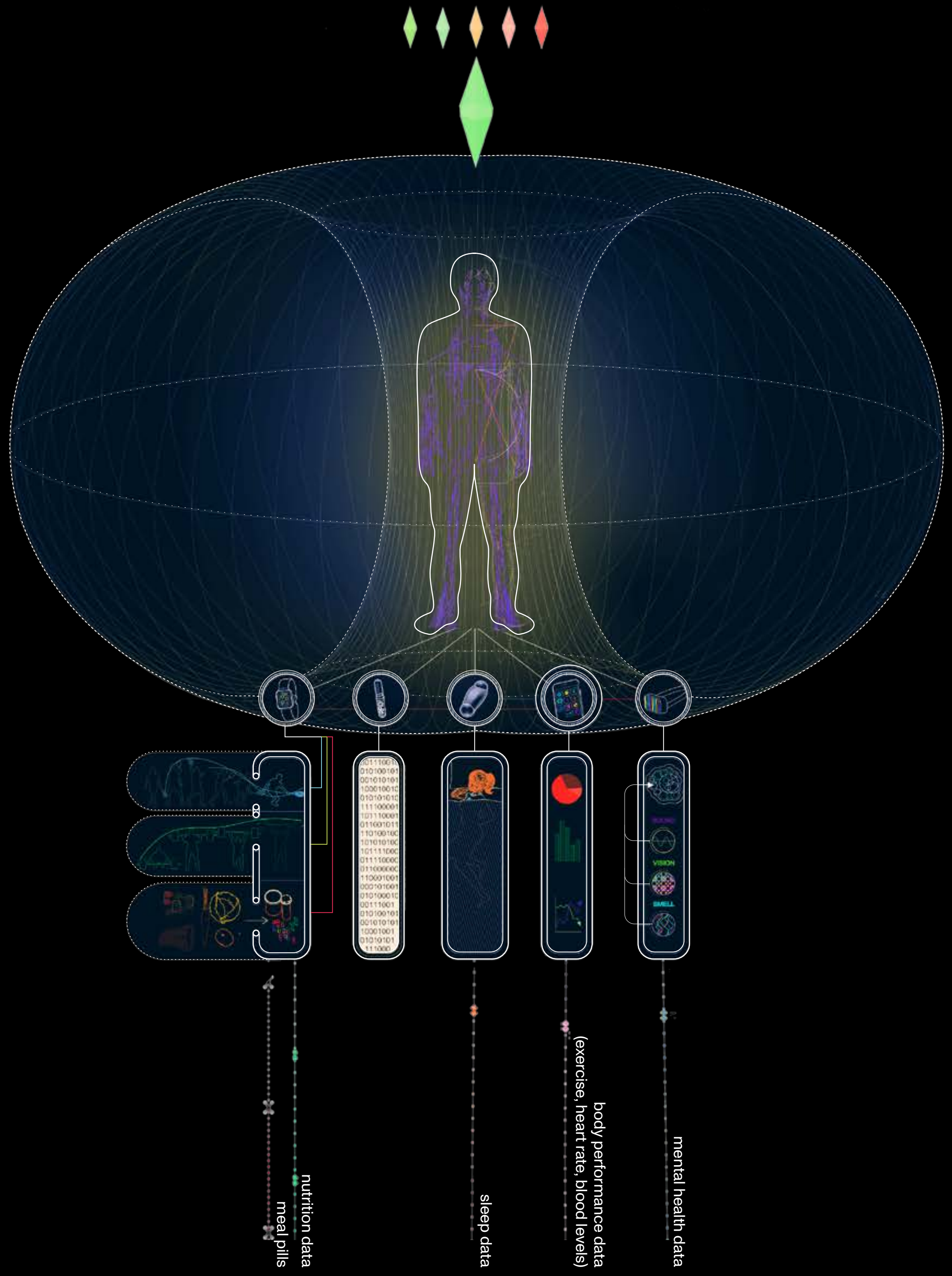


Fig. 5 Zoom in on 'The future architecture of health care' chapter 'Wearables'.

Wearables allow for a vicious circle of care. Body performance data is collected by the devices and shared with the human to improve the body's performance. Next to collecting and sharing data, Wearables allow for precision medicine, telehealth, and AI to operate under the most efficient circumstances. Wearables help humans maintain their' physical and mental health. The devices track the body's performance. The data is shared with AI and specialists to advise, update and guide a human to stay healthy.

A NETWORK FOR DEMOCRACY

I-Hsuan Lee, Susanne van de Pol, Robert Bichlmaier

The way urban space is created and secured has undoubtedly changed since the terrorist attacks at the beginning of the twenty-first century. Security and surveillance became a frequent subject of discussion. Some elements in our everyday life, like barricades blocking entrances to public events as protection from terrorist attacks (such as the one that happened on a Christmas market in Germany in 2016), are easily recognizable as barriers in the space of conflict. The intrusion of surveillance into public and private life has certainly affected the way people move and act in the urban environment.

Taking the act of protesting as an example, the urban environment becomes the stage of conflict. Opposing ideologies and political positions physically come face to face in the public space. Often in the form of citizens expressing their dissatisfaction with the current government or political system. In recent years, news about political protests around the world has become more frequent, with the pro-democracy movement in Hong Kong and Black Lives Matter demonstrations as recent and ongoing examples.

To understand the impact of technology on our cities, as spaces of conflict in political protest, we investigated the 2019/2020 Hong Kong protests, specifically looking for the technological means used by the government and protestors alike and how those technological means led to a new way of protesting, organizing bodies, tactics and collectives.

Increasing surveillance capabilities, paired with facial recognition programs enabled by artificial intelligence, give the government a strong authority over the information concerning ongoing events in the city. It is possible to track nearly every corner of the public space from the comfort of a control room. Protecting their identity by wearing masks and disabling/attacking CCTV cameras are actions that the protestors employed. At first glance it seems that there is a strong imbalance in authority over the information gathered in the urban landscape, but the protestors managed to communicate efficiently by using peer to peer mesh networks, which enabled them to adapt to situations quickly. This efficient way of organization without the need of a designated leader is the main difference when comparing the current protests in Hong Kong with previous events like the 2014 Occupy movement. Following a quote by one of Hong Kong's most famous citizens, Bruce Lee, 'Be like water', the protestors were always on the move, quickly adapting to every new situation, while blocking parts of the city by building barricades fast, 'on the fly'.

With our design, we want to enable the tactics even further by proposing a city-wide Bluetooth mesh network. This network can be expanded by everyone who wants to participate. They can add devices like Bluetooth repeaters, storage or sensors to the network and thus enhance it in numbers and range. The effectiveness of the network is increased as more people participate, no matter if they're physically disabled or not, making it a democratic tool for the pro-democracy movement! The authority of information is no longer tied to the city's infrastructure of CCTV networks and data centres. Anyone can contribute, giving the authority over information and narrative back to the protestors, thus effectively formulating a counterproject to the official surveillance system by surveying the actions of the government itself.

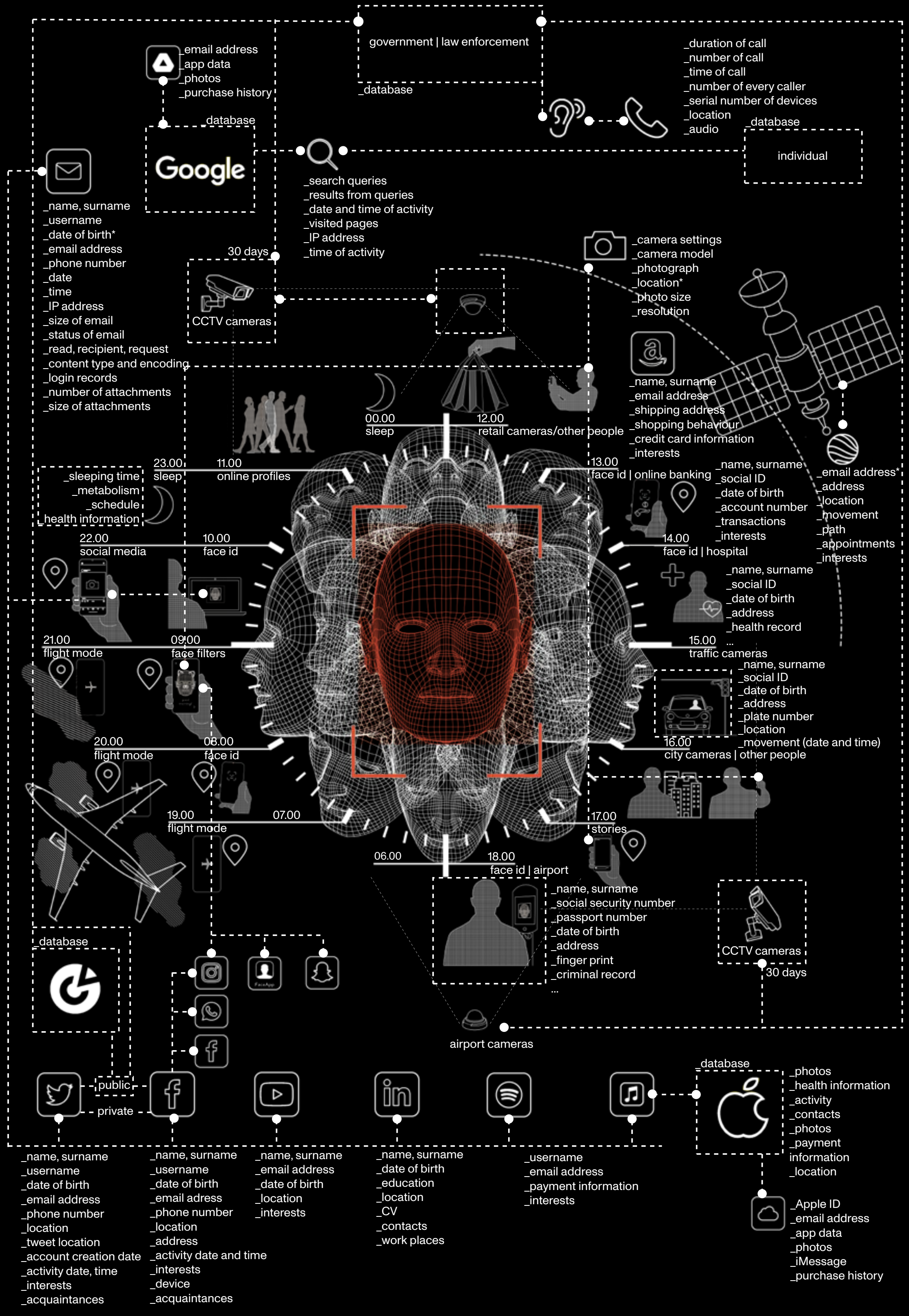


Fig. 1 Interlinked network of online personal data and everyday face recognition surveillance encounter. Drawing by Ali Fatih Gebeci and Dilara Turgut.

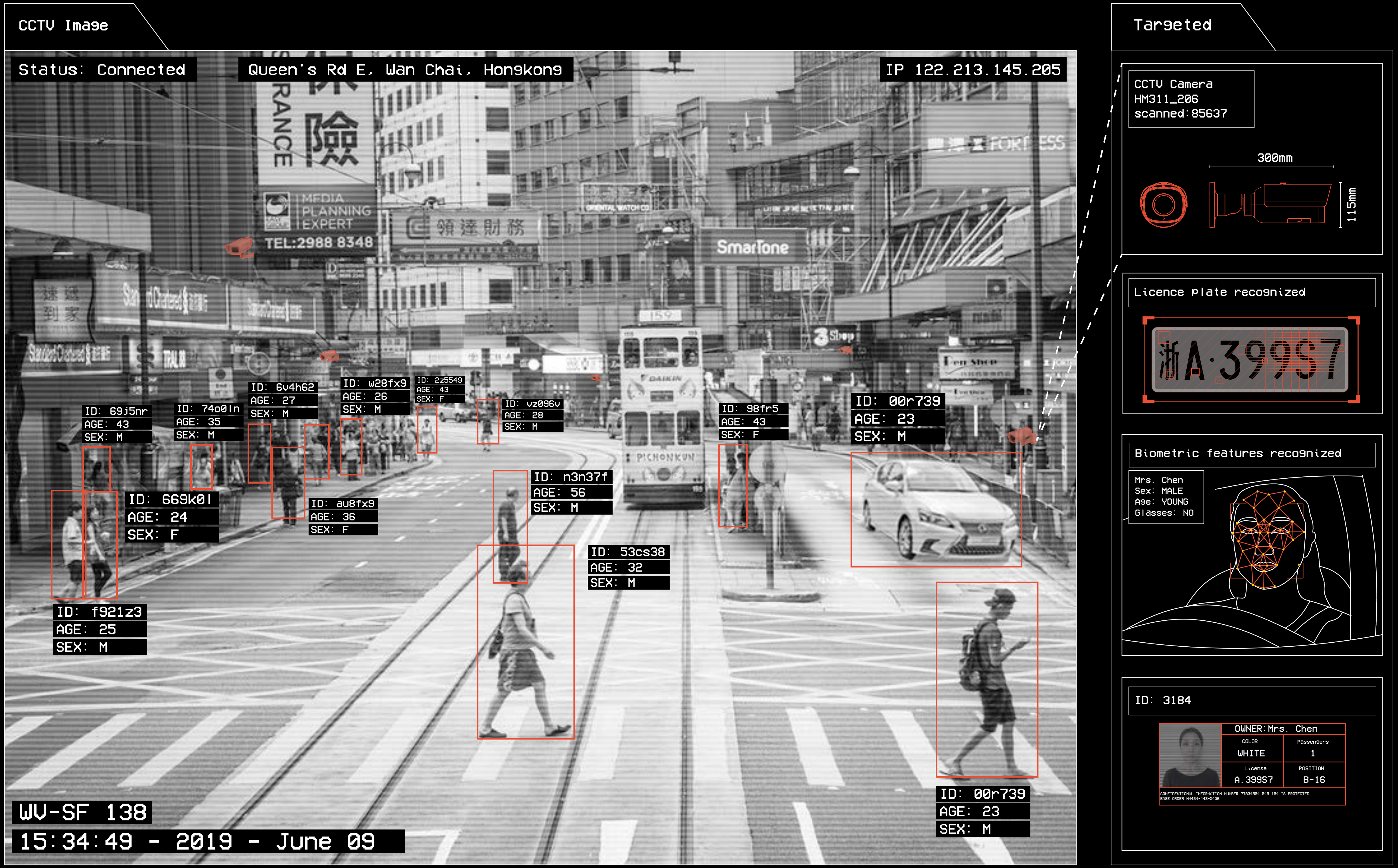
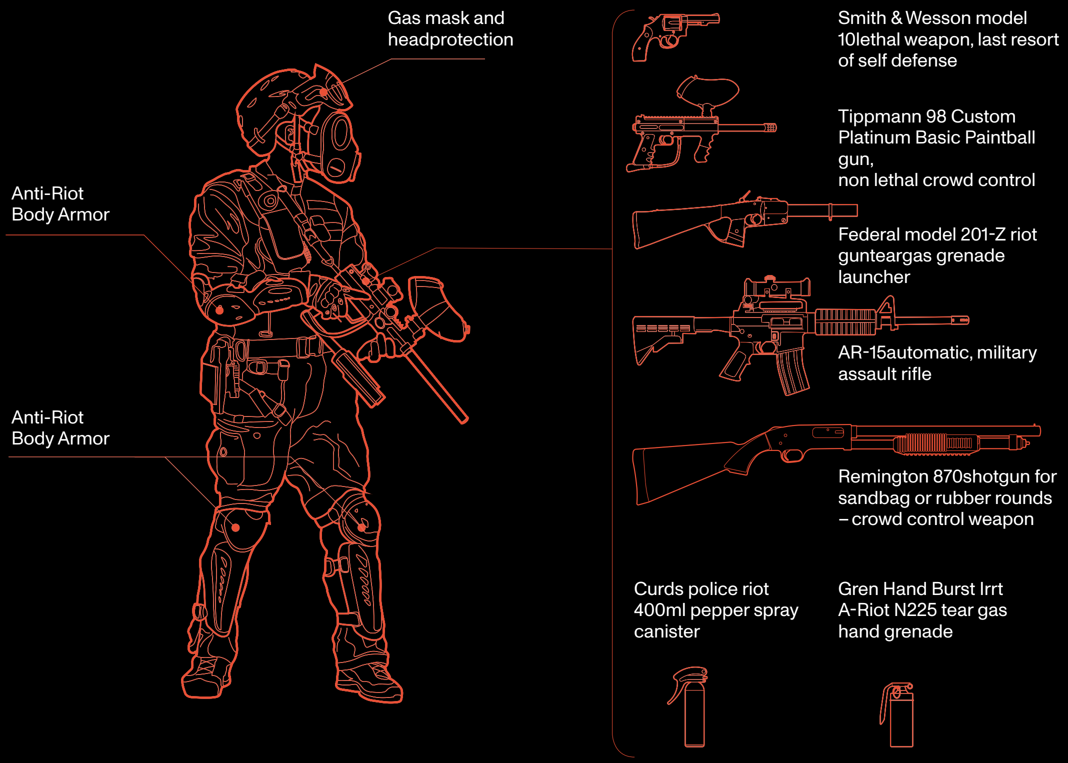


Fig. 2 Surveillance diagram, ‘if you have nothing to hide, you have nothing to fear’.



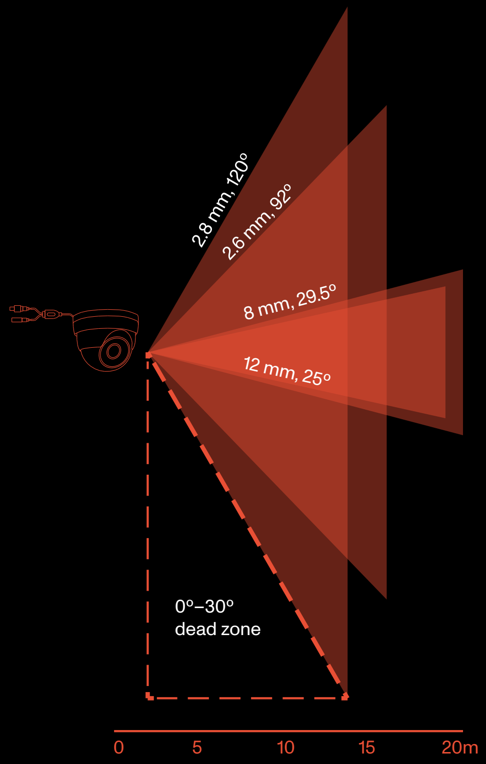
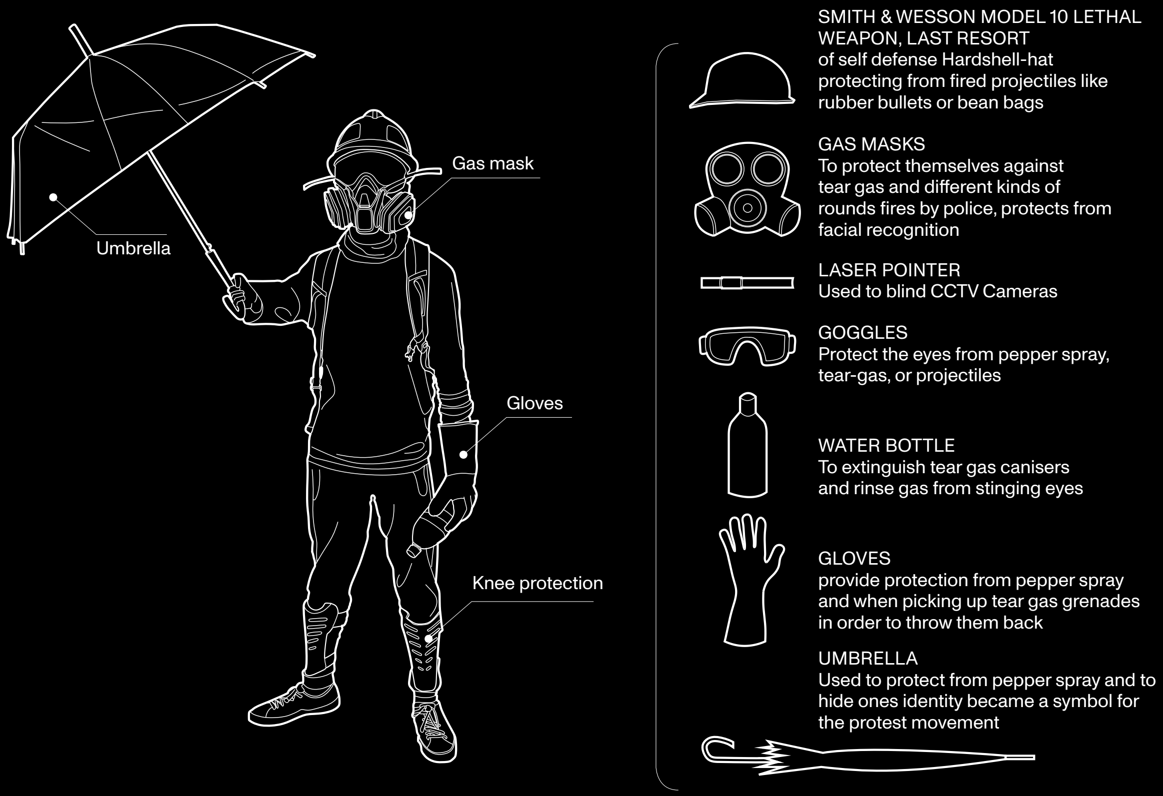


Fig. 3 ↑↑ Policeman with accessible equipment. ↑ CCTV recognition zone.



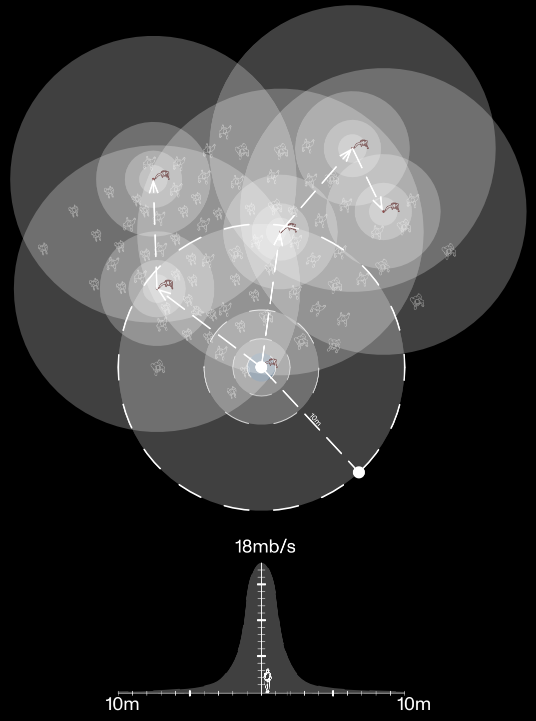


Fig. 4 ↑↑ Protester with accessible equipment. ↑ Bluetooth area range. Decentralized Network using Apples Airdrop technology Searching for close devices (10m) with Bluetooth. , directly connecting after request is accepted with Wifi for fast connections.

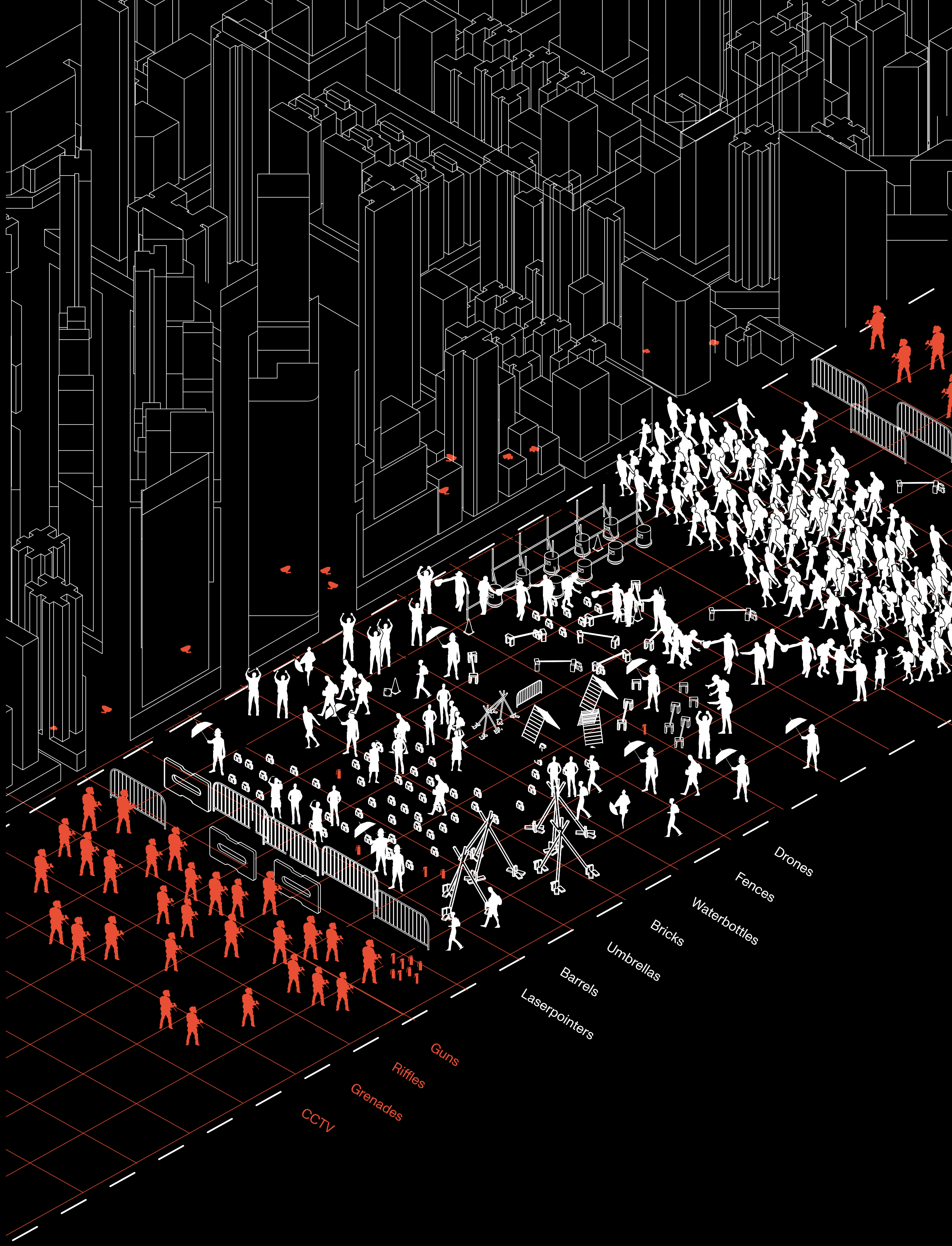


Fig. 6 Layering protest in Hongkong streets: city scape, battlefield, in conflict.

META-OFFICE

Lauritz Bohne, Lea Scherer, Edward Zammit

What we think of as artificial intelligence is often manufactured by the routine clicks of countless workers. Hidden behind their screens they operate the digital production line of a rising labeling industry focused on data description services—services that seem to be automated but are in fact deeply human. Amazon employs workers from all over the planet that are paid cents per minute per task to label, categorise and validate vast arrays of raw data, providing the important meta-data. The so-called Amazon Mechanical Turks are the unseen workforce behind digital automation.

By using Amazon's crowdsourcing platform to enter into a dialogue with its workers, Meta Office exposes their decentralized 'office' spaces. While the workers are confronted with the mechanisms of the platform, they allow us a voyeuristic gaze into the most intimate interiors, where individual needs bend to those of work.

Photo by photo, the workers share with us which objects are most meaningful to them, revealing a repetitive pattern: desktops, mice and keyboards, office chairs, tables and trays, headphones, extension cables and desk fans meet bedrooms, kitchens and bathrooms, beds, pillows, and refrigerators.

Click by click, the workers provide information about square metres, geographical location or earnings, expanding our understanding of the photographs with their metadata.

Meta Office merges the physical imprint of that digital production line, whose common ground is the transformation of space itself: an improvised making of a workspace with all the means at its disposal. An office space that imposes itself, transforming its original surroundings into a working environment whose appearance does not resemble a corporate design, but underpins the influence of a globally operating corporation. An individualised and continuously expanding office space whose existence, just like that of its workers, remains concealed behind countless generic User-IDs.

Meta Office is what it is described as.

The meta office is self-descriptive. The task of its employees is the recording of their offices, being domestic interior spaces. The description of their environment defines it at the same time: Description becomes construction, heavily dependent on the subjective perception at this very moment. As such, the project applies the method of crowdsourcing, and pushes its boundaries further, becoming a method itself.

Meta Office is pure visualization.

The design challenges architecture as pure visualization applying different tools of spatial mapping. The visual reproduction of the explored decentralized spaces is seen as an act of centralization that allows us to understand their physical implications as a whole.

Meta Office is perceived from within.

The mapped (office) interiors are qualified by their objects. Once all these objects were interior objects of living rooms, sleeping chambers, kitchens, or bathrooms. Domestic objects became objects of work. The workers employ them to serve them in order to build up their office. Their transmutable interrelations define the program of the space.

Meta Office is meta-data.

It is statistics, labels, numbers, categories and quantities. It is size, location, effort and time—m2, coordinates, $ and sec. As the effort of its workers completely lies in the creation of these data, the meta office is never complete. As the meta office is constant description, it can never be described fully.

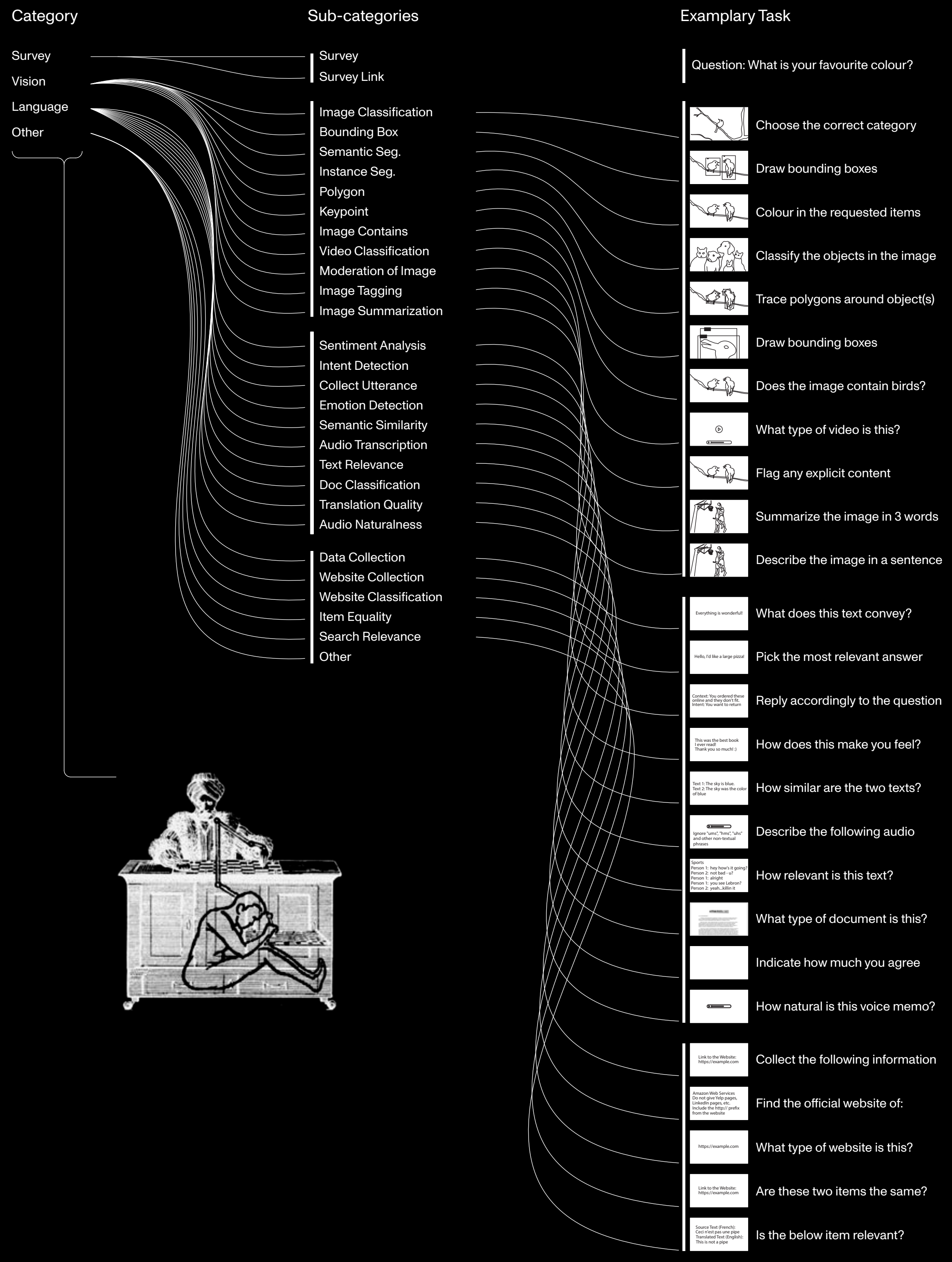
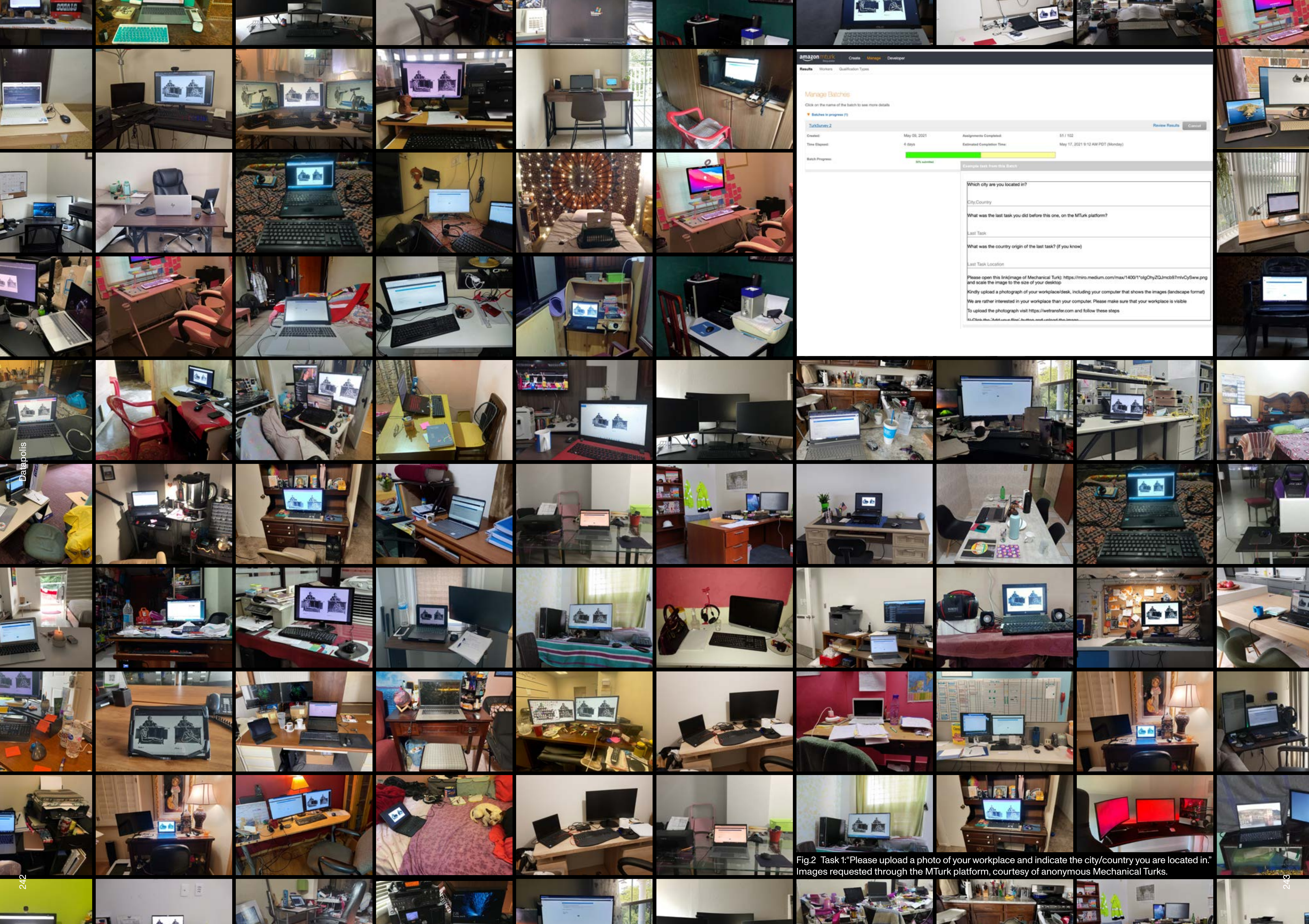


Fig.1 Interfaces of the labelling industry.
Index of various tasks that can be performed by the Mechanical Turk.



Manage Batches

Click on the name of the batch to see more details

▼ Batches in progress (1)

TurkSurvey 2

Created: May 09, 2021

Time Elapsed: 4 days

Assignments Completed: 51 / 102

Estimated Completion Time: May 17, 2021 9:12 AM PDT (Monday)

Batch Progress: 50% submitted

Example task from this Batch

Which city are you located in?

City,Country

What was the last task you did before this one, on the MTurk platform?

Last Task

What was the country origin of the last task? (if you know)

Last Task Location

Please open this link(image of Mechanical Turk): https://miro.medium.com/max/1400/1*olgOhyZQJmcb97mlvCySww.png and scale the image to the size of your desktop

Kindly upload a photograph of your workplace/desk, including your computer that shows the images (landscape format)

We are rather interested in your workplace than your computer. Please make sure that your workplace is visible

To upload the photograph visit https://wetransfer.com and follow these steps

Fig.2 Task 1:"Please upload a photo of your workplace and indicate the city/country you are located in." Images requested through the MTurk platform, courtesy of anonymous Mechanical Turks.

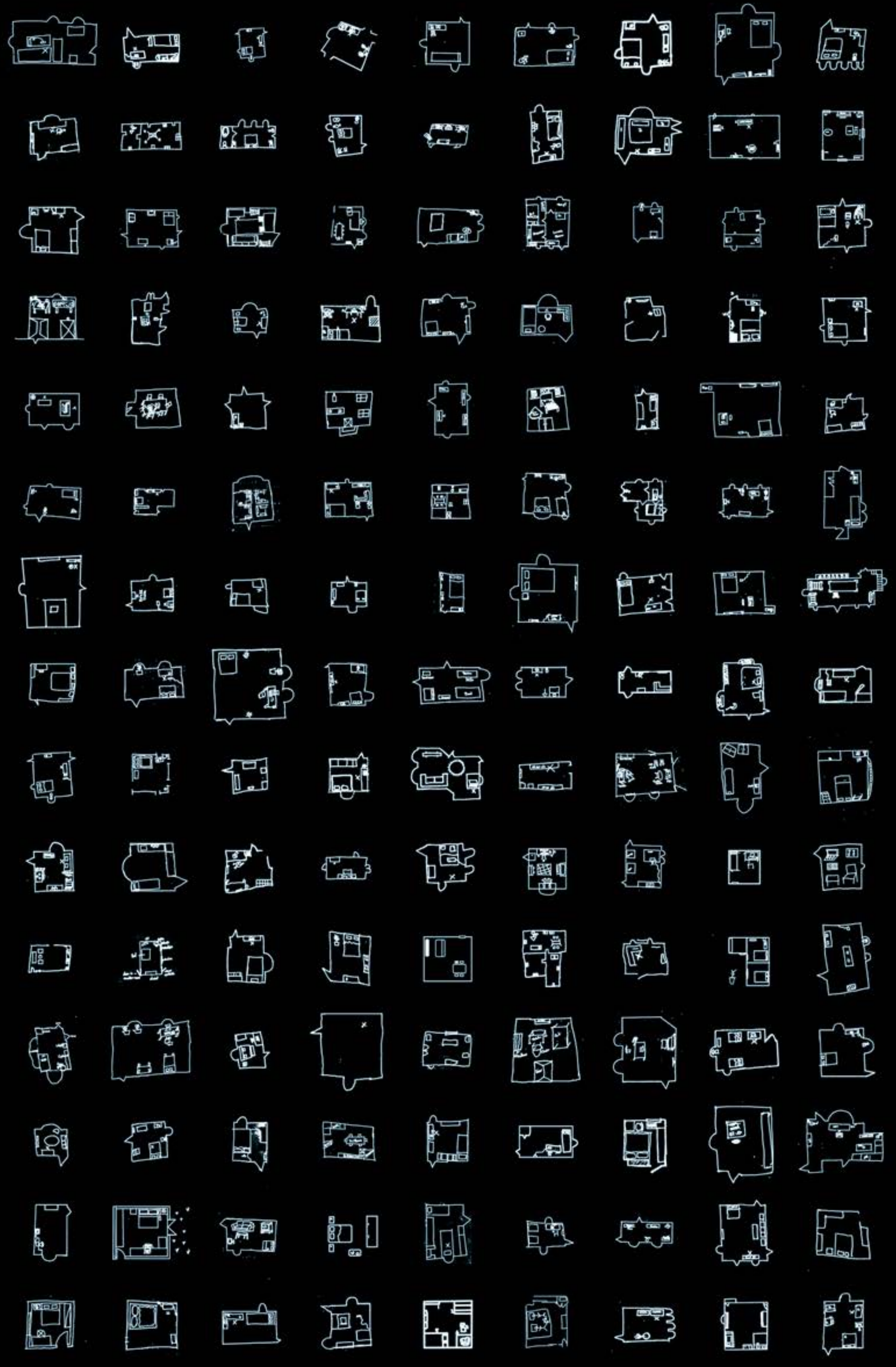


Fig.3 Database of the Mechanical Turks' office floor plans, hand-drawn by anonymous Mechanical Turks. The drawings were collected and compiled by authors and they were requested through www.mturk.com.

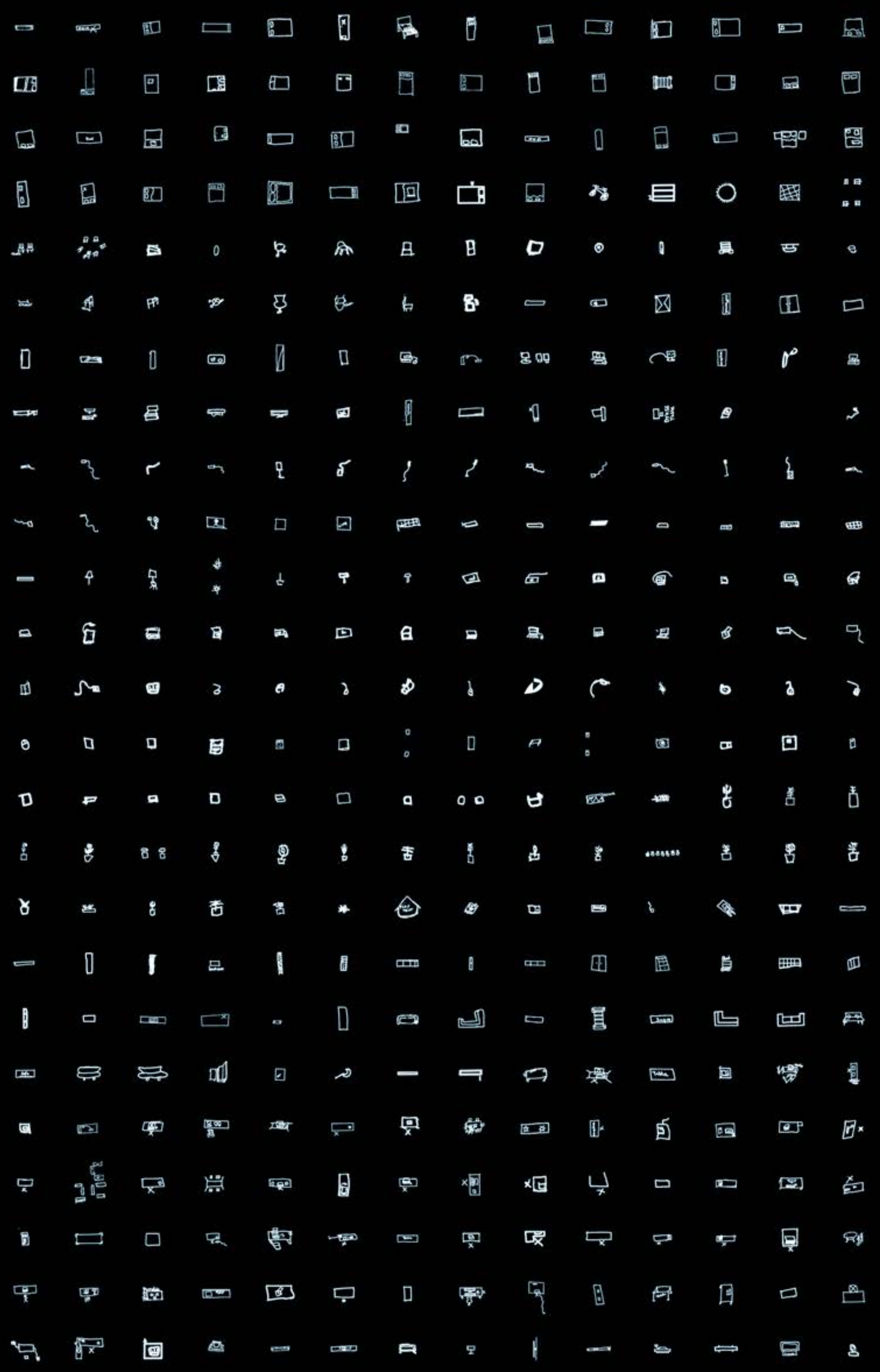


Fig.4 MTurks' office tools.

NL, Roermont
desk
$0.25
855 sec

USA, Dallas
television
$0.25
1876 sec

France, Perpignan
vacuum cleaner
$0.25
1449 sec

France, Grenoble
plant
$0.25
1679 sec

Spain, Madrid
storage
$0.25
618 sec

Brazil, Salvador
sidetable
$0.25
855 sec

Italy, Naples
sofa
$0.25
2269 sec

France, Grenoble
extension cable
$0.25
834 sec

Venezuela, Merida
bed
$0.25
1233 sec

India, Hyderabad
chair
$0.25
705 sec

USA, New York
laptop
$0.25
2638 sec

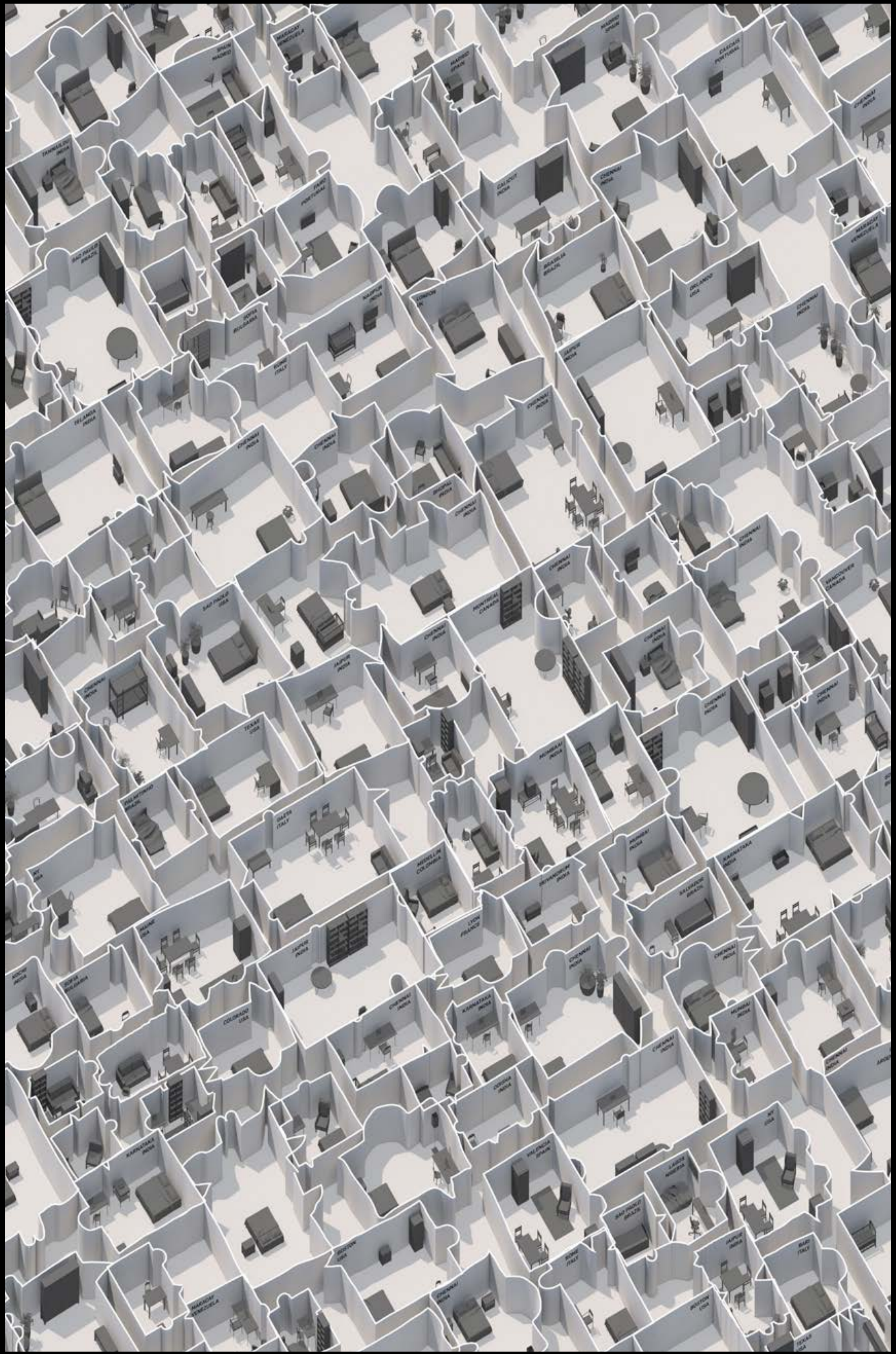
India, Chandigarh
mouse
$0.25
2112 sec

Z1
Brazil, Guarulhos
fan
$0.25
855 sec

Y3
Brazil, Sao Paolo
water
$0.25
801 sec

Z2
India, Chandigarh
electric heater
$0.25
947 sec

Fig.5 ↑ Database of the Mechanical Turks' chosen objects. A series of photos of each object were requested from each MTurk.Through photogrammetry, each object was converted into a 3d model and catalogued by the authors.
Fig.6 → Task 5: 'Meta Office is all of you in one building. How does the building look like?'



ORGANICA: NOETIC HORIZONS OF DATA

Rafał Tarczyński, Ragna Nordström

Organica explores the possibilities of existing with technicity while reconnecting to our inherent spirituality. A spirituality that has been enabled through the evolution of information and communication and specifically the evolution of the digital. The project we are proposing is not just an organic data centre, it extends into the surrounding territories, potentially constructing healing datascapes. These datascapes in turn offer their inhabitants a monistic way of coexisting, technicity and nature reunited, reconnected, re-ligare.

The purpose of this research is to analyse transformations of religious thought throughout history and more specifically systems of belief related to the rapid spread of information and communication technologies in contemporary society. We are interested in the digital, in humans and in the effect of technology on humans. How does the use of technology and the authority of Big Data affect our lives? How does it change our relationship to the world and our relationship to other humans? What can we learn from our religious heritage in terms of ethical and moral thinking?

The question of authority and free will has been contemplated throughout every period of Western history and philosophy. The term 'free will' emerged as the common concept of designation of control over one's actions. Subsequent questions that emerged in regard to this topic concern the nature and existence of this same control as well as questions surrounding the significance of this control—for what reasons it might be of importance and whether it is essential for moral and ethical reasoning. The idea of a global biotechnical network is elaborated by Howard Bloom in The Global Brain.[1] Since the birth of the personal computer, scientists have been working on this global brain composed of computer networking. This radical human transformation began by attaching billions of minds of humanity together into a single system. Nearly 20 years ago, Bloom predicted a collective consciousness where we all come together in a global network that has learned our ways of thinking and can provide us with the knowledge we need before we even know we want it. A network that will turn the planet into a single spiritual super-being, a massive 'collective consciousness'.

By recultivating the land with organic infrastructure, biodiversity and habitats can recover. This is a way for humans to coexist with nature without losing the accessibility of information and technicity. The organic data centre works as the focal point of this society. It is the main source and creator of the landscapes and the society. It functions so that it can attach to any data flow: undersea cables, underground networks and to external power grids, thus allowing for floating, digging and flying. Its main task is to translate as much binary data as it possibly can into organic form and then return it to the land, thereby 'pollinating' the Earth with new organic data. The programme of the structure responds to the simple unity: one part belowground, which reacts to the intake of binary data, and one part aboveground, which responds to an output of organic information through the cultivation of plants, bacteria and minerals. The intersection of technicity and nature can also be observed when the data is retrieved. How would such an interaction be visualized? The Apostles of Data are provided with a starter pack consisting of portable devices to decode data from datascapes.

The starter pack comes with a backpack with integrated solar panels for charging the devices. The device for plants is equipped with a DNA sequencer that analyses an inserted sample and decodes text and audio files. While lying and resting in the picturesque landscape, you can listen to the sound of the flowers.

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[1] Howard K. Bloom, Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century (New York: Wiley, 2000).

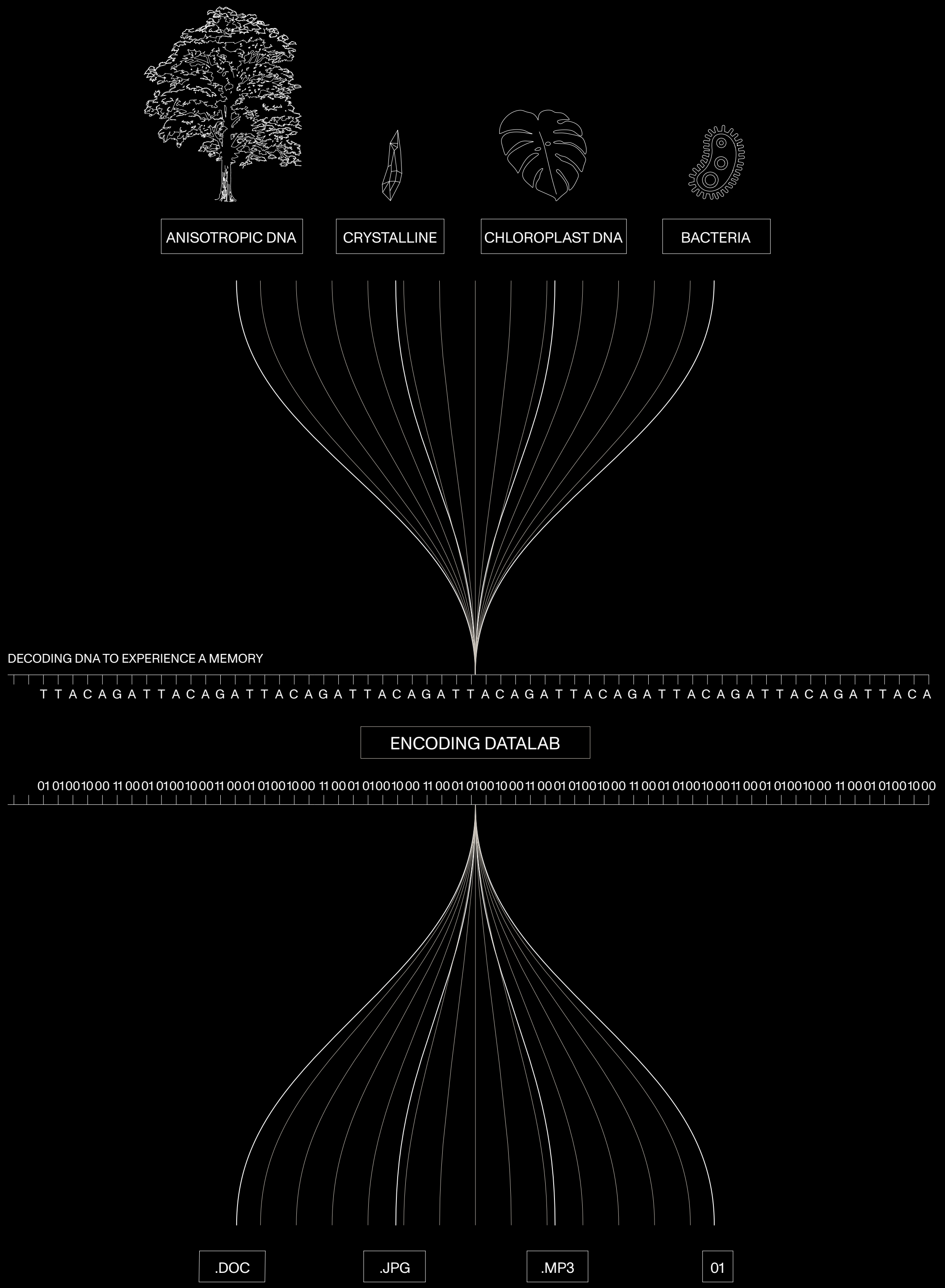


Fig. 1 Any binary file can be translated into autotroph DNA, bacteria's DNA and crystalline structures.

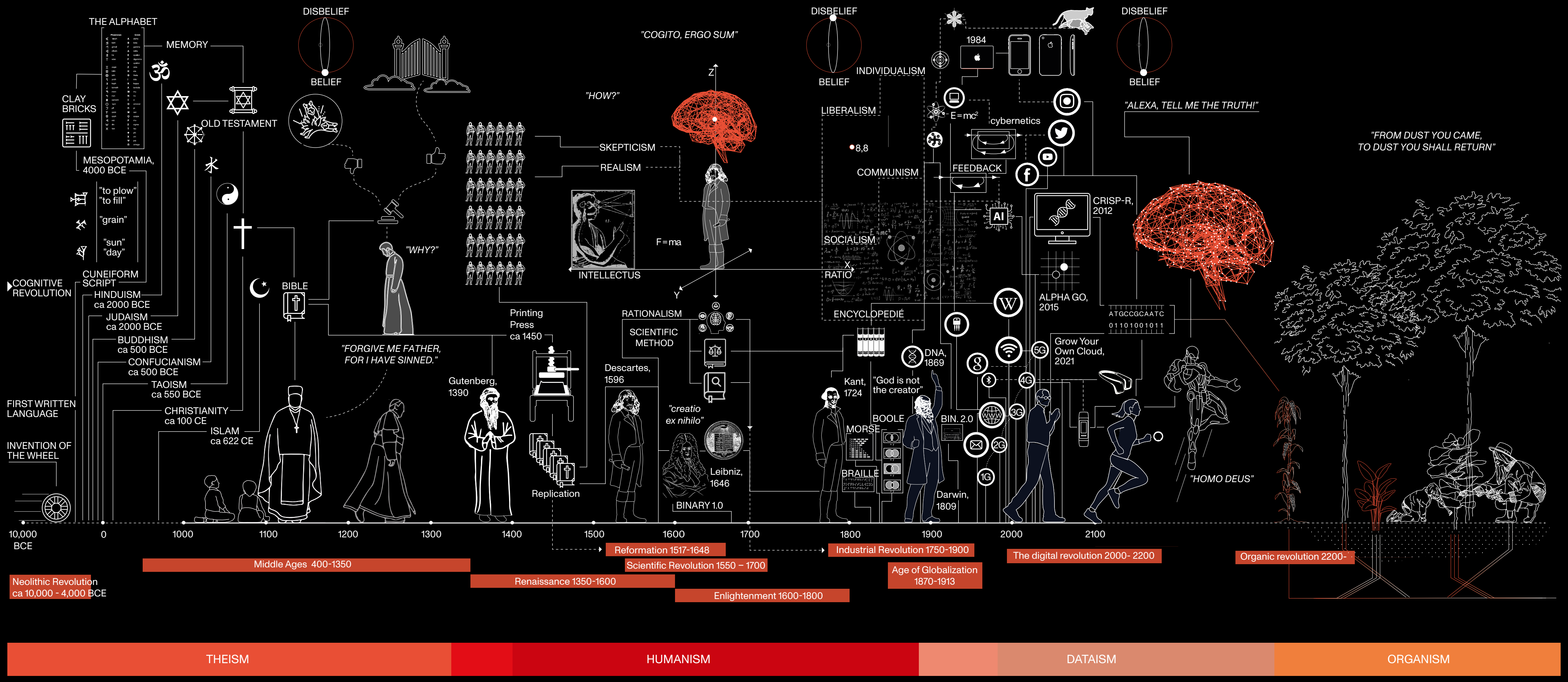
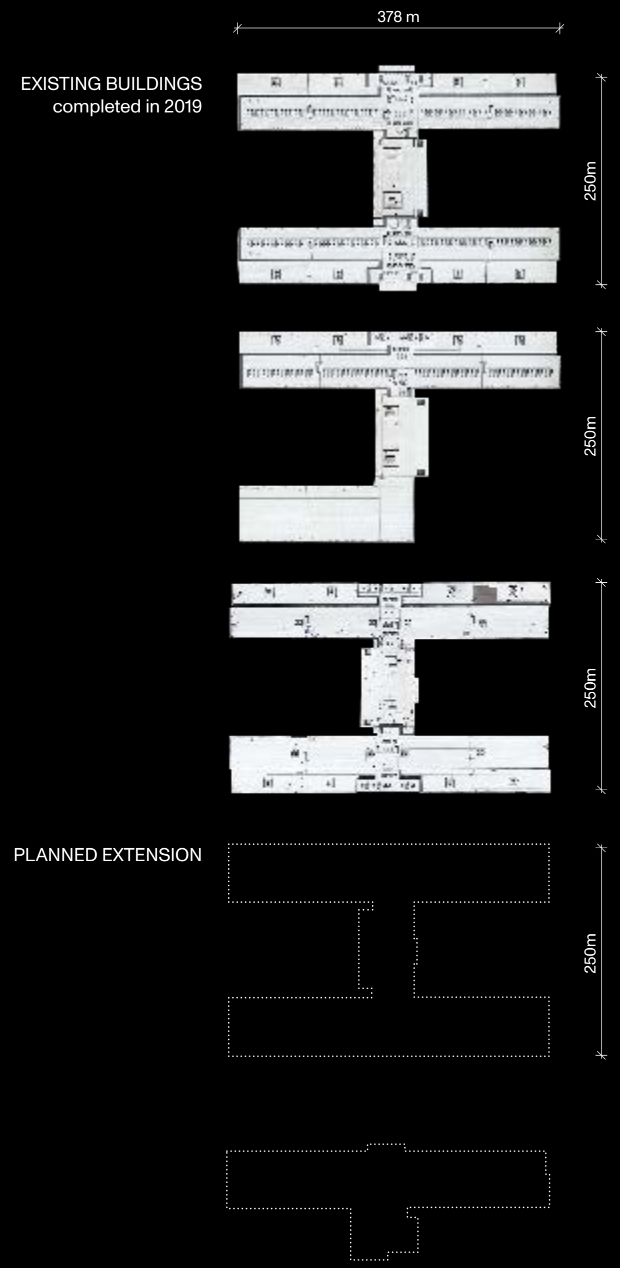
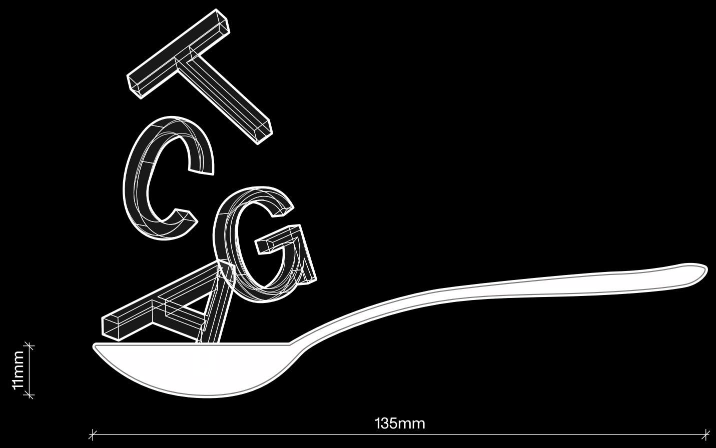


Fig. 2 The timeline shows an alternative future of data, where data is transferred back to the Earth.

Source: Yuval N. Harari, Homo Deus: A Brief History of Tomorrow (London: Harvill Secker, 2016); Yuval N. Harari, 21 lessons for the 21st century (New York: Random House Audio, 2018); Shawn DuBravac, Digital Destiny (Washington DC: Regnery Publishing a Salem Communications Company, 2015); Kevin Kelly, What Technology Wants (New York: Viking, 2010); Jonna Bornemark, The Renaissance of the Immeasurable (New York: Meridian Books, 2018); "History of Writing System", Britannica, accessed 2021-05-12; "Big History Project", Khan Academy, accessed 2021-05-12.



SURFACE OF THE DATA CENTER: 371.600 m2
ENERGY REQUIRED TO OPERATE THE DATA CENTER: 310 MW
LIFESPAN OF A SERVER: 3–5 years



ESTIMATED VOLUME OF TODAY'S WORLD DIGITAL DATA: 64.2 zetabytes
NECESSARY AMOUNT OF DNA TO STORE IT: 20g
LIFESPAN OF DNA STORAGE (AT IDEAL PRESERVATION TEMPERATURE): ~1.5 million years

Fig. 3 Comparison of META's latest Sarpy Data Centre in Sarpy County, Nebraska (USA) & DNA Data Storage Footprint. Source: DNA has a 521 year half-life, Matt Kaplan. Nature (2012).

Fig. 4 Envisioned landscape of Orgánica: a Noetic Horizons of Data.

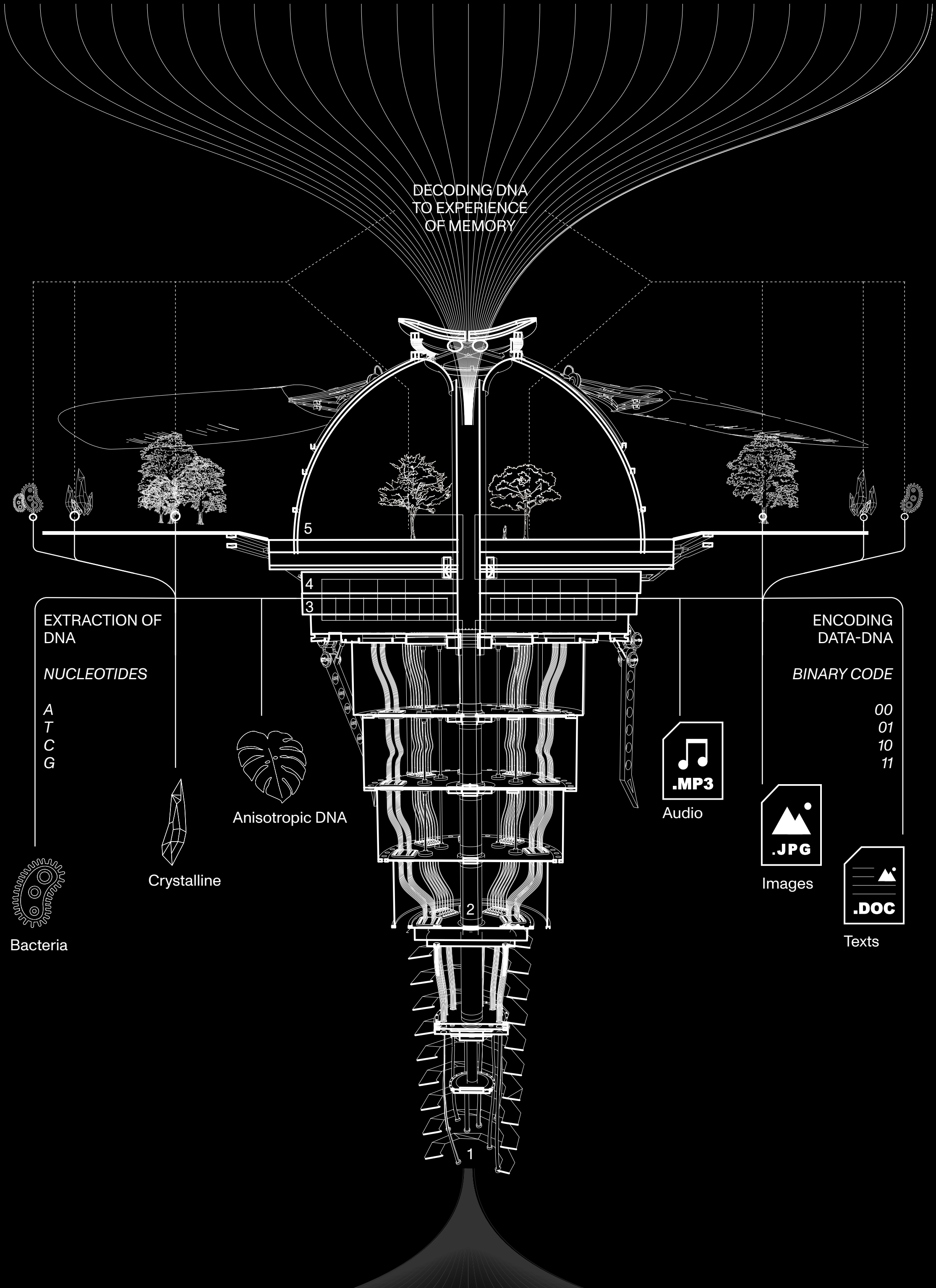


Fig. 5 Section of the organic data center:

1 Binary Data intake from underwater cables
2 Water cooling system
3 Data servers for temporary storage of binary data before encoding
4 Bio-data lab for DNA encoding
5 Greenhouse for cultivation of plants before re-planted outside

BIOGRAPHIES

Ali Fard is a researcher, designer and educator, currently an assistant professor at the University of Virginia School of Architecture. Fard's work operates at the intersection of design and urban processes. He is particularly interested in the spatial imprints of technology and the urban disposition of infrastructure, and how design research can help ground the operational complexity, spatial hybridity and territorial scales of large technical systems. Though his design research practice AF/DR, Fard has been involved in a range of award-winning projects globally that reinforce design's critical and multiscalar role in the territorial dynamics of contemporary urbanization.

Georg Vrachliotis is Full Professor and Head of Chair for Theory of Architecture and Digital Culture, Department of Architecture, TU Delft. From 2016 Georg was dean of the Karlsruher Institut für Technologie (KIT) Faculty of Architecture and Chair for Architecture Theory (2014–2020). Previously he conducted research at the Institute for the History and Theory of Architecture at ETH Zürich. He studied architecture at the Berlin University of the Arts and did his PhD at the ETH Zürich. Besides that Georg was a visiting researcher and lecturer at the UC Berkeley Department of Architecture in California and the TU Wien in Vienna. Georg Vrachliotis is member of the advisory board of the magazine ARCH+, external examiner at Bartlett School of Architecture, UCL London, and academic advisory board member of the *Jaap Bakema Study Centre* at *The Het Nieuwe Instituut*, Museum for Architecture, Design and Digital Culture in Rotterdam. Georg Vrachliotis is the author and co-editor of several books on the history and theory of digital culture in architecture, such as *Complexity. Design Strategy and World View* (2008), *Simulation. Presentation Technique and Cognitive Tool* (2008), *Patterns. Ornament, Structure and Behaviour* (2009), *Code. Between Operation and Narration* (2010), and *Datatopia* (ARCH+ special issue, 2019). He recently published *The New Technological Condition: Architecture and Design in the Age of Cybernetics* (2022). Georg Vrachliotis curated the exhibition "Fritz Haller. Architect and Researcher" at the SAM Swiss Architecture Museum in 2014 in collaboration with the Institute for History and Theory (gta) at ETH Zurich (catalogue published by gta Publisher in 2014, with Laurent Stalder), the exhibition "Sleeping Beauty. Reinventing Frei Ottos Multihalle" (catalogue published by Spector Books in 2018) on the occasion of the 16th International Architecture Exhibition of the Venice Biennale in 2018. He recently curated the exhibition "Models, Media and Methods. Frei Otto's Architectural Research" at the School of Architecture at Yale University (2020).

Gökçe Önal is a doctoral candidate at the Faculty of Architecture at Delft University of Technology, with the research group Borders & Territories. She taught at METU and at Delft University of Technology and contributed to TU Delft's Massive Open Online educational portal as a course developer. She is currently an assistant editor for 4S Backchannels. Her doctoral research investigates the agency of remote sensing practices in the production of spatial knowledge.

Jeroen van Loon is a Dutch artist researching and visualising digital culture through the lens of ephemerality and permanence. His work has been exhibited internationally at venues such as Centre Pompidou, Transmediale, IDFA Doclab, Aksioma, Centraal Museum, HMKV | Dortmunder U, IMPAKT festival, Verbeke Foundation, SPRING performing arts festival, Nemo Biennale, V2_, KIKK Festival and MU Artspace. He received the K.F. Hein Art grant, the European Youth Award, was nominated for the New Technological Art Award (NTAA) 2022 and is part of the Brave New World Speaking Agency as a speaker on art and technology. Van Loon (b. 1985 in 's Hertogenbosch, The Netherlands, lives and works in Utrecht, NL) received a bachelor in Digital Media Design and a European Media Master of Arts from the HKU University of the Arts Utrecht.

Joost Grootens is a graphic designer, educator and researcher. Based in Amsterdam (NL) and Biel/Bienne (CH), his studio SJG designs books, maps, typefaces, spatial installations and digital information environments for publishers, including Lars Müller Publishers, nai010 publishers, Park Books and Phaidon press; for educational and research institutes such as ETH Zurich, Future Cities Laboratory Singapore, Technical University of Munich and Delft University of Technology; and for museums like Astrup Fearnly Museet Oslo, Serpentine Galleries London and Van Abbemuseum Eindhoven. Grootens is Professor of Artistic Research in Visual Design at the Royal Danish Academy in Copenhagen and formerly the head of the master programme Information Design at Design Academy Eindhoven and university lecturer at Leiden University. Grootens studied architectural design at the Gerrit Rietveld Academy Amsterdam and obtained his doctorate from Leiden University. His research addresses the transformation of the fields and practices of graphic design and mapmaking resulting from technological changes in tools to record, create, edit, produce and distribute visual information.

Kees Kaan founded KAAN Architecten in 2014. Kaan graduated in architecture at Delft University of Technology in 1987. Kaan is Chair of the department of Complex Projects at the faculty of Architecture at Delft University of Technology since 2006. In 2019 Kaan was appointed Chairman of the Architecture Department. Moreover, he has been Principal Investigator at Amsterdam Institute for Advanced Metropolitan Solutions (AMS) since 2016. Kaan is an international lecturer Numerous books and exhibitions have been dedicated to his body of work.

Marija Marić is an architect and researcher, working as a postdoctoral research associate at the Master in Architecture programme, University of Luxembourg, where she also teaches. Marija has been appointed as a co-curator of the Luxembourgish Pavilion at the 2023 Architecture Biennale in Venice, with the project that critically unpacks space mining through the perspective of resources. In 2020, she obtained her doctoral degree from the Institute for the History and Theory of Architecture (gta), ETH Zurich. Her dissertation, titled *Real Estate Fiction: Branding Industries and the Construction of Global Imaginaries*, looked into the role of communication strategists in the mediation, design and globalization of the built environment. Marija's research is organized around the questions of architecture, real estate, media and technology, and the production of the built environment and urban imaginaries in the context of global capitalism and the global flow of information.

Marina Otero Verzier is the head of the Social Design Masters at Design Academy Eindhoven. The programme focuses on new roles for designers attuned to contemporary ecological and social challenges. From 2015 to 2022, she was the director of research at Het Nieuwe Instituut (HNI), the Dutch Institute for Architecture, Design and Digital Culture. At HNI, she led initiatives focused on labour, extraction and mental health from an architectural and post-anthropocentric perspective, including 'Automated Landscapes', 'BURN OUT: Exhaustion on a Planetary Scale' and 'Lithium'. Previously, she was the director of Global Network Programming at Studio-X, Columbia University GSAPP, in New York. Otero was a co-curator at the Shanghai Art Biennial 2021, curator of the Dutch Pavilion at the Venice Architecture Biennale in 2018 and chief curator of the 2016 Oslo Architecture Triennale. She has co-edited *Lithium: States of Exhaustion* (2021), *More-than-Human* (2020), *Unmanned: Architecture and Security Series* (2016–2020), *Architecture of Appropriation* (2019), *Work, Body, Leisure* (2018) and *After Belonging* (2016), among others. Otero studied at Delft University of Technology, ETSA Madrid and Columbia University GSAPP. In 2016, she received her PhD from ETSA Madrid.

Natalie P. Koerner (1987) is assistant professor at the Royal Danish Academy of Architecture (Copenhagen) and at the Centre for Privacy Studies at the University of Copenhagen, a Centre of Excellence funded by the Danish National Research Foundation (DNRF). Koerner combines research with teaching at the master's programme Spatial Design where she is responsible for running the first semester. In her practice, she builds and works on artistic research projects. Koerner has worked for several firms, including the artist Studio Olafur Eliasson. She studied architecture at the University of Cambridge (2005–2008), at the ETH Zurich (2009–2011), and received her PhD from the Royal Danish Academy (2015–2019). Her thesis *Towards the Meteorological: The Architecture of Data Centres and the Cloud* linked notions of a planetary imaginary to digital archival practices.

Negar Sanaan Bensi is an architect, educator, and researcher. She is a lecturer at the Architcture faculty, TU Delft , the chair of Borders & Territories. She holds a Ph.D. in History and Theory of Architecture from TU Delft and she is an UKNA fellow. She received an honourable mention in the National Archiprix 2011 in the Netherlands for her master graduation project. Her research focuses on the relation between architecture and territory, infrastructure, and inhabitation, specifically in the context of the Iranian Plateau and the Middle East. She has taught at TU Delft, Tilburg Fontys and Rotterdam Academy, Syracuse University NYC, and lectured at the University of Antwerp and IIAS in Leiden. She is part of the editorial board of the Footprint Journal and online Modi Operandi publication series (B&T). Some of her recent publications are: the upcoming book *An Inhabitable Infrastructure: Rethinking the Architecture of the bazaar* (Routledge), "The Qanat System: A Reflection on the Heritage of the Extraction of Hidden Waters" in *Adaptive Strategies for Water Heritage* edited by Carola Hein and *Footprint #23: The Architecture of Logistics* as the (co)editor. She is part of the research group "Borders & Territories" in the Architecture Department at TU Delft. She has experience in practice individually and in collaboration with several offices such as ZUS [Zone Urbaine Sensible], Import. Export Architecture, and GFC.

Paul Cournet is a French architect based in Rotterdam, The Netherlands. In 2022, Paul founded CLOUD, a creative agency that focuses on architecture, research and design. He is also the deputy editor of Capsule—the International Review of Radical Design & Desire Theory—a new publication delving into the world of design and its broader definition. Previously, Paul worked at OMA*AMO as a Senior architect between 2010 and 2021. At OMA, Paul worked on several projects currently under construction or built such as the future headquarters of SNCB*NMBS in Brussels and Lafayette Anticipations, the cultural foundation for Galeries Lafayette in Paris. Paul also worked within AMO, the think-tank branch of OMA. Projects Paul worked on for AMO include the Pierre Paulin Program exhibition in Bordeaux (2019), the Palermo Atlas—an urban study for the art biennale Manifesta 12 (2018), exhibitions and set designs for the fashion house Prada, and Monditalia—an exhibition for the 14th architecture Venice Biennale titled Fundamentals (2014).

Paul Swagerman is graduated in Visual Communication from the AKI, academy for Art and Industry. He has a broad interest in visual communication, cartography, infographics, photography, visual identity and multimedia design. Paul has the talent to bring together project content and representation in a readable and insightful way. Paul worked for, amongst others, ZUS [Zones Urbaines Sensibles] Architects, Artist Melle Smets (Department of Search), Bureau B+B Landscape Architecture, Kraaijvanger Architects, Maas Architects, LOER Architects, ECHO Architects, Musician Joris Voorn, Villa Zebra, art museum for children, Exhibition designers Koehorst in 't Veld, website builder Fotomat, and Ydoc Foundation, Platform for Visual Storytelling.

Sabrina Chou is a Taiwanese-American artist and writer from Los Angeles, USA. She received her doctorate in practice-led art at the University of Oxford. Currently she is a lecturer in Critical Studies Fine Art at Central Saint Martins in London and a research affiliate of the Research Network for Philosophy and Technology. Sabrina holds an MFA from the Piet Zwart Institute in Rotterdam and a BA in Visual and Environmental Studies from Harvard University in Cambridge. She has presented her work internationally in exhibitions and performances, at, for instance, Human Resources Los Angeles, the 6th Moscow International Biennale for Young Art and Het Nieuwe Instituut. She has been an artist-in-residence at Centre International d'art et du paysage Île de Vassiviere and Sitterwerk Foundation. Sabrina writes on theory and art, including in *Thresholds 48: Kin* (MIT Press, 2020) and *Ringgummimatte* (Spector Books, 2021).

Shannon Mattern is a Professor of Anthropology at The New School for Social Research. Her writing and teaching focus on archives, libraries, and other media spaces; media infrastructures; spatial epistemologies; and mediated sensation and exhibition. She is the author of *The New Downtown Library: Designing with Communities*, *Deep Mapping the Media City*, and *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media*, all published by University of Minnesota Press. In addition to writing dozens of articles and book chapters, she also contributes a regular long-form column about urban data and mediated infrastructures to *Places*, a journal focusing on architecture, urbanism, and landscape, and she collaborates on public design and interactive projects and exhibitions.

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The Cloud is

the new infinity

10–11

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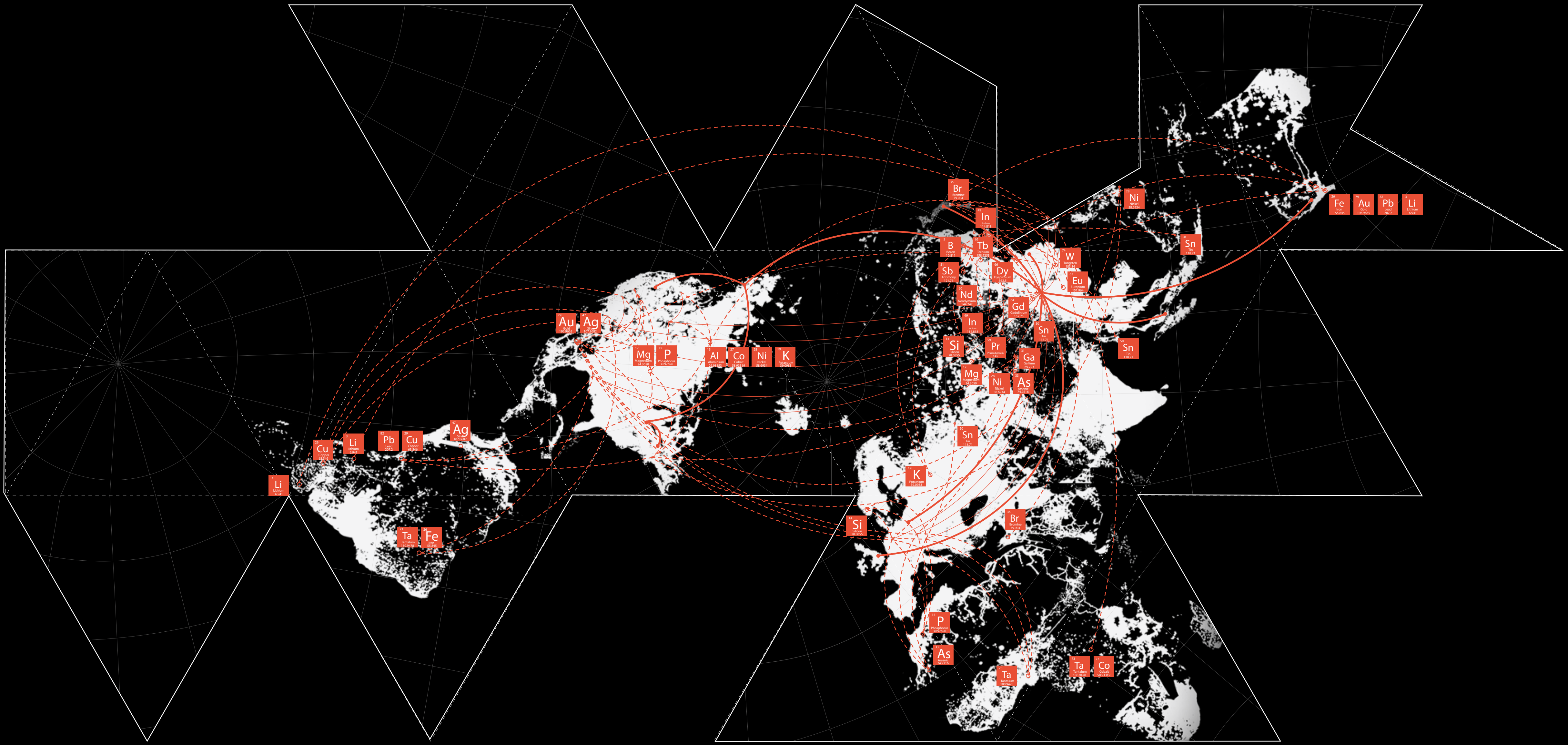
JOURNEY OF AN IPHONE



- - - Raw Material Flow
— Component Flow
— Product Flow
○ Mine
● Component Manufacturer
● Distribution Centre
● Apple Selling Point

Starting from raw material extractions, component refining, and manufacturing process, to the distribution in worldwide's stores, your iPhone travels 800,000 km to reach your pocket. A smartphone contains around more than 34 raw materials, where seven of the 34 were classified as 'critical raw materials' or rare earth elements by the EU commission in 2014. Drawing by Jeremy Li Ho Kong and Alice Chau Ka Yee. Source: Jay Greene/CNET.