

Cargo Drone Manifesto.
J.M.Ledgard

CARGO DRONE MANIFESTO

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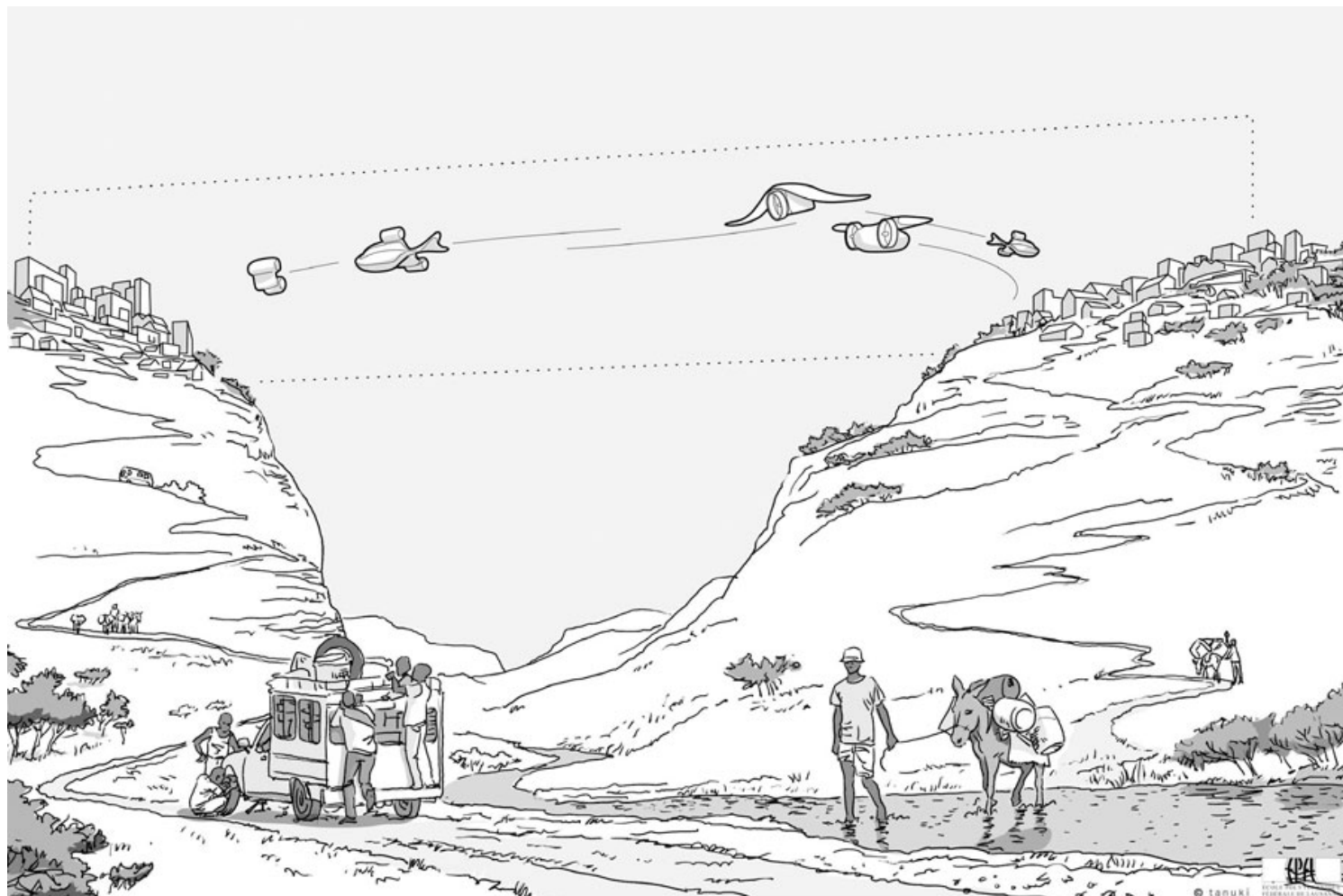
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Better use of the lower sky in a sharing economy.



The Year 2024 design by S. Shiraishi.

MBALE, Uganda - My goal is to help set up the world's first commercial cargo drone route in Africa by 2016. It will be about 80 kilometres long and will connect several towns and villages. The first cargo drones will carry small payloads — probably units of blood to keep alive children who would otherwise perish. But they will quickly evolve into larger and heavier craft until they can lift 20 kilos or more over distances of several hundred kilometres. The purpose of the first route will be to show the value of cargo drones in Africa and beyond — and to raise money to build other routes.

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To me, this first route is a spectral version of the Liverpool and Manchester railway.

I am a novelist, but I am also director of a future Africa initiative at the Swiss Federal Institute of Technology and for the last decade I travelled Africa as a foreign correspondent for The Economist newspaper. I was one of those who reported that Africa is rising, not falling. I want to detail here what I mean by cargo drones and the reasons why I think throwing up time dependent goods into the sky and moving them about with a flying robot is a good idea in Africa — and beyond.

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Manchester - Liverpool first railway line.

The Future will be Radical

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The first point to make is that, even if we deride change, even if we stand still, shielding our eyes, covering our ears, the future will be radical. I spent my time as a foreign correspondent reporting on politics, economics and war, but I came to see that the most important stories in Africa were not news stories at all. On the one hand, rapid human population growth and extermination of other species. On the other, introduction of advanced technologies capable of reordering time and space. Indeed, the mobile phone is the reason I now spend time in robotics, computing and mathematics labs.

The mobile phone is one such technology. It has contributed more to anti-poverty efforts than any single development intervention. Some development agencies were slow to wake up to the possibilities of the technology in Africa. They argued that handsets would always be too expensive for the poor and besides, how could a village incapable of taking care of a grain silo ever look after a mobile phone tower? But the price of handsets came down and investments in mobile phone towers showed that if the system is valuable enough, the system will protect itself .

Even mobile phone operators underestimated the market. The business plan for the Kenyan telecom Safaricom in 2003 was to have 500,000 mobile phone subscribers by 2013. These would be traders, priests, taxi drivers, prostitutes —people willing to pay a premium to stay in touch. But Safaricom now has 21 million users. To emphasise: the uptake of advanced technology was 42 times greater than it was expected it to be. When I think of what cargo drones can and should be I think of the Nokia 1100 mobile phone. Over 50 million Nokia 1100s were sold in Africa. Smart, rugged and cheap the handset was known as the Kalashnikov of communication, but where the machine gun tore at the fabric of society the handset created new possibilities.



I keep this picture of the Nokia 1100 pinned up by my desk as proof of the paradox which undergirds cargo drones — the paradox of advanced technologies which I believe will come to define the early 21st century: a community will have access to a flying robot even though it will not have access to clean water, or security, or be able to keep its girls in school. What is technically scaleable will be scaled, what is not scaleable will have to be fought for, household by household. Another way of saying this is, what will improve lives in Africa most easily will be a technology intervention that is massively scaleable.

A Cargo Drone is a Donkey

For many people, drone is an ugly word. It evokes a whining sound, something insectile. The dislike of the drones themselves is understandable. It is a new technology, used mainly for killing or peeping. However, this early negative feeling will begin to shift with positive use cases for drones. Before 2020, drones will take over search functions at sea. Never again will a coastguard helicopter go blindly into the night in search of a sinking ship. Instead, it will be guided by a drone sent ahead of them to locate those in peril. Drones will monitor the wellbeing of crops and animals. They will be used in mapping, counting, policing, and sports. And they will also lift things.

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I spent a moonlit evening last year around a campfire in a Samburu manyatta in northern Kenya. It was a fresh night, very beautiful, the stars wheeled above us, we could trace the course of the satellites. There was a softness and warmth of goats all around. The manyatta was circled with a wall of thorns to keep out the lions and hyenas. The nearest road was several hours drive away by Land Cruiser. We were trying to explain to a Samburu elder the concept of a robot programmed to fly up into the air and deliver a load of whatever you wanted. The Samburu was straining to understand the term robot. A mechanical creature, I said, not a beast, not a camel. It was slow going. Then at last he leaned back and laughed. "I see! You want to put my donkey in the sky!" He had many donkeys. The Samburu like to load them with water and firewood. They walk steadily down

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dried up river beds, over mountains, through brush. My colleague, Simon, and I knew instantly he was right: we really did want to put his donkey in the sky.

The qualities of a donkey are similar to what is required for a cargo drone: surefooted, dependable, intelligent, able to deal with dust and heat; cheap, uncomplaining. The choice of the name donkey for cargo drones is deliberate. A donkey is not a Pegasus, associated with speed. It does not bomb, does not monitor. It flies stuff between here and there, that is all. The first routes presage the future railways in the sky, but they are also the equivalent of the donkey paths that wind up through wooded mountains in some parts of the world, cresting at a remote village, then winding down the other side.

In the early years there will be different types of airframe, each with their advantages. Most common will likely be drones which switch between VTOL and fixed wing, using rotors for precise take off and landing and switching to fixed wing to save energy in flight — just like these Google experimental drones.



Google experimental drones.

There will be plain fixed wing and soft wing designs, parasails, zeppelins, and oversized quadcopters and octocopters. As regulatory and certification demands are satisfied, airframes will carry donkey-sized loads over 80 kilometres in an hour.

Cargo drones are a supplementary transport system, not a disruptive one. You cannot move people by drone — not yet. They are pointless for last mile delivery of the kind envisaged by Amazon Prime Air and many other drone developers: in Africa, the last mile is a child walking to school with a backpack. Nor is it likely within our lifetimes that cargo drones will be competitive with the low cost of arterial road and rail transport. They are about the middle — a medium sized vehicle shifting medium sized loads medium distances between middle sized communities. To be seen to have value to the community and not be a threat, they will need to create jobs not just in the productivity

gains they afford but in and of themselves. Loading and maintenance will be labour intensive. A donkey in the sky does not do away with a donkey on the ground, anymore than it negates the value of a motorbike, or a bicycle. But they can improve health and emergency services, connect markets, and grow industry in Africa at a critical moment in its history.

To match the massive scale of the Nokia 1100, cargo drones will have to be built with fewer parts, less maintenance, and at a lower cost than any aerial vehicle yet conceived. The unit cost for a large cargo will need to be close to the price of a decent off-road motorbike in Africa — around \$4000. Several trends have converged to make this price point possible: mass production of parts for the smartphone industry foremost, but also pervasive cloud computing, new wireless data links, new powertrain technologies, local manufacturing and hacking, open source designs, and the rise of drone makers. Nevertheless, the combination of bargain price and space probe level performance remains an extreme engineering challenge.

Some assumptions need be met. The first is that donkeys can be made safer than manned flight. They will need to be capable of flying unmanned, without a pilot even on the ground, carrying the necessary redundant systems, and be able to land instantly and safely if a route is compromised. They will have to be able to deploy airbags and parachute solutions to slow and still a tumbling airframe in the event of failure. And they will need to do all this while matching the performance of organisations like the British charity riders.org which runs African health ministry motorbikes 50,000 kilometres over five years without a preventable breakdown. The second assumption is that donkeys can be built to be silent and beautiful in the sky, so that humans looking up from the ground will regard them either neutrally or with pleasure. Electric motors and noise cancellation will be required to achieve quietness: drones simply cannot drone.

What is it to be a beautiful drone? They might have a sheen and colours which can alternately hide them against the colour of the sky, or cause them to shimmer like a shard of the firmament. They might draw on biorobotics to imitate birds, dragonflies, or the drift of octopus underwater, in all cases avoiding settlements, moving along the rivers and the keeping to the edge of the jungle, freeing up land and nature. On every route, they will be less intrusive on the landscape than electric pylons and wind turbines.

This will take time and experimentation. Industry standards for donkeys will rely on technology transfer from industry as well as on invention and tinkering by young African engineers and hardware hackers. For the first route, drones will often be flown in groups to rapidly deliver lifesaving treatments.

Their initial disappointing size will be limited by the battery technology and the need to prove to authorities that donkeys can be both safe and secure. The regulatory, security and insurance risks associated with cargo drones are significant. Government will have to have oversight of loading and be able to immediately drop down a donkey in case of security risks. However, the biggest hurdle to the technology is the emotional demand of having a donkey flying over your head. In this regard, I find it helpful to think about sky.

What is Sky anyway?

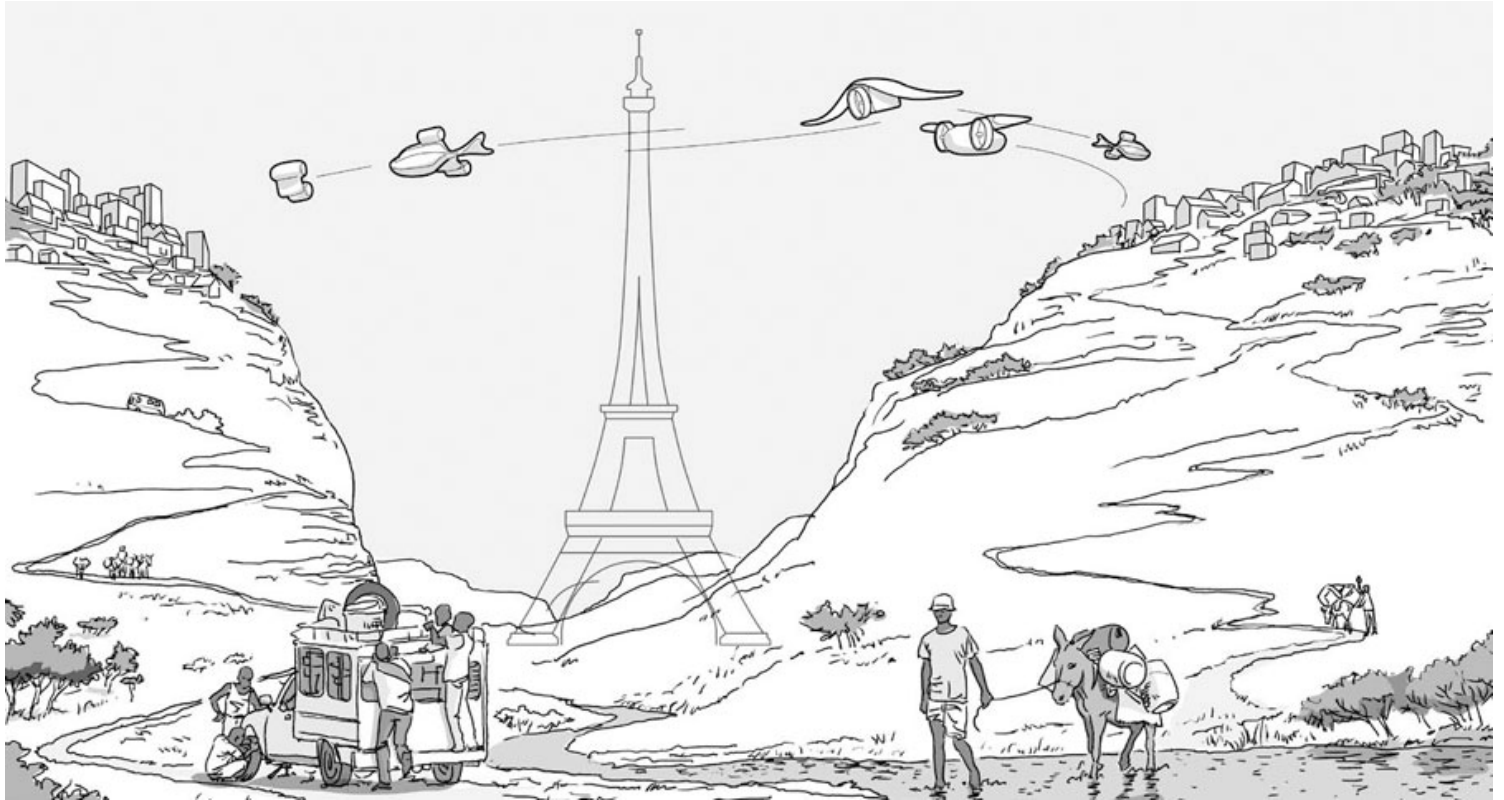
As a species we have hardly begun to think what is above our heads. We have no word to describe the volumetric space in the sky. Whatever the language, sky is invariably not about sky at all. What we see is what is on it, like stage scenery. Virgil talks of sky as an extended void through which you shoot a fleet arrow. This gets close to our modern sense of sky as something to move through at speed, to foreshorten, and our vertiginous fear of it; something so thin, the gravity so severe, the speed of the arrow going up, and the plunging of the airliner pell-mell to the ground. We talk about atmosphere, stratosphere, airspace. But none of the words say much about the porousness between the rooftops and the clouds, the bit of the sky we breathe, walk through, and look out upon. The English word sky comes from the Old Norse word sky meaning cloud. In Old English the word became scio, meaning region of clouds. For those living in England, this made sense. The English sky is heavy, invariably overcast and dramatic, the clouds low and dark. In Old English heofon meaning heaven was interchangeable with sky. We still talk about the heavens opening. In German, the word himmel means both sky and heaven. That reinforces the view of the clouds as the home of the gods, latterly of Christ, his angels, and hell being in the magma below our feet, and the ground being the present realm of volition and purpose. There is some discomfort in us, of not wanting to get anything between our heads and the source of light and ascension. But the point is that there is plenty of space up there. There are whole continents up in the air for the right kind of drones to traverse. The sky above Sudan is stacked with virtual Sudans.

How might a donkey route look? The easiest way to picture it is to take the Eiffel Tower and draw a line from the top of the tower.

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Donkey Flights design by S. Shiraishi.

Donkeys will fly roughly at that Eiffel height, in what I call the lower sky. The routes will be geofenced: donkeys will only be able to fly in an air corridor about 200 metres wide and 150 metres high. Busier routes will resemble a high-speed ski gondola, without cables or supporting structures.

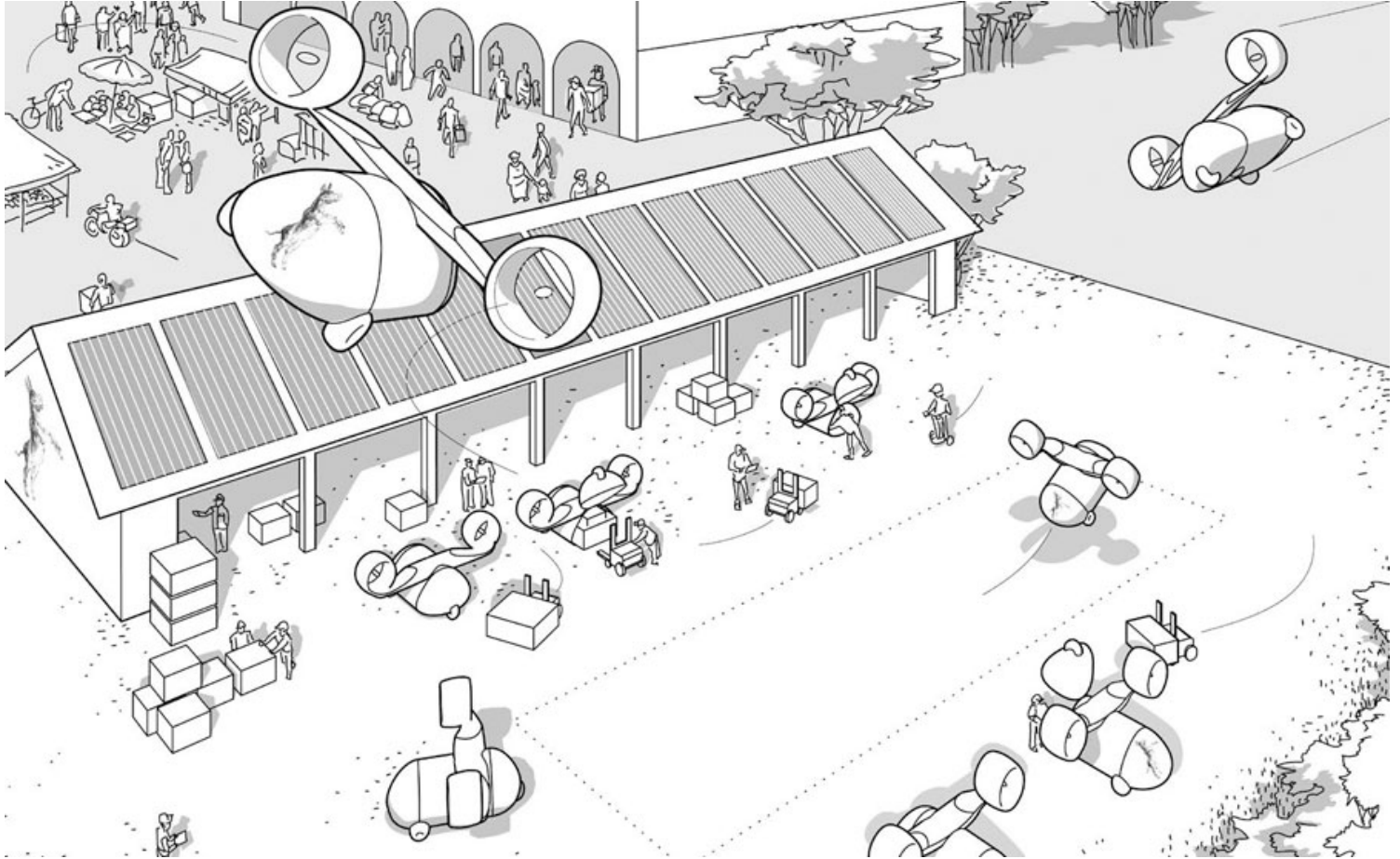
Every small town will have its own clean energy donkey station like the one below. The traffic to and from it will mostly be on foot and bikes. The stations will serve as the petrol station of the near future. They will incorporate postal and courier services.

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Donkey Station design by S. Shiraishi.

Repair shops will mix 3D printing and other advanced technology with low tech, presaging a Tatooine future where neural circuitry and simple materials will be matter-of-factly combined. The stations will provide business opportunities for African startups and for architects. In contrast to the concrete petrol stations built around Africa in the colonial period, donkey stations could nudge communities away from settlements strung out alongside roads to something safer and quieter. Since donkeys will eventually operate on batteries, the renewable energy arrays needed for clean recharging will also power surrounding homes and businesses.

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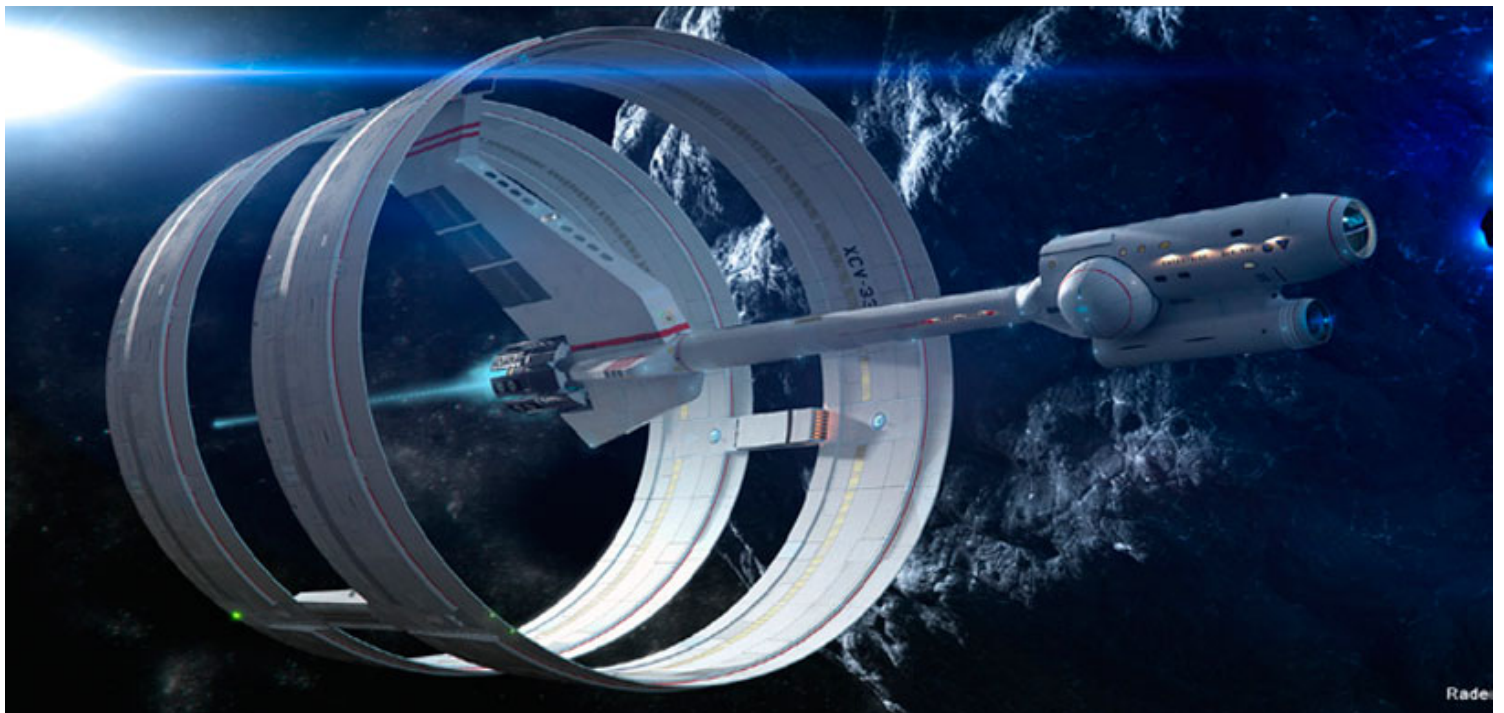
The Time is Now

The next decade will be among the most decisive in Africa's recorded history. Fertility rates in the largest African countries are not falling as fast as had been predicted. At the present rate Africa's population will be 2.7 billion by 2050, against 228 million in 1950. To have a chance of prosperity, African economies need to quickly turn growth into manufacturing jobs. The problem is that they are growing, but not transforming. Growth rates are much too low. In key economies like Nigeria, Kenya and Senegal manufacturing is dominated by small, informal firms. The poorest countries seem to be de-industrialising. New factories, such as in Ethiopia, will not offset the dumping of cheap finished goods from Asia on African markets. There has never been an African owned car maker of any size. Almost every motor vehicle used on the continent has been built on another continent. Some economists suggest they will not begin to converge with industrial countries before 2060 . Simply put, Africa is not catching up.

The biggest risk for Africa is the unmet expectations of its youth. Half the population is under 19 years old. The ratio of African youth to European youth will increase from 2.2 to 1 to 4 to 1 before 2025. The World Bank suggests that 75% of these young Africans will fail to find a salaried job in the next decade. Most will survive on day labour or subsistence farming. They will not know where their next money is coming from. They will be easily knocked flat by mishaps or illnesses. Some will get handouts from relatives, some will turn to crime and scavenging. Yet this generation of Africans will be better educated than any gone before them. Most of them will have access to wearable and implanted computing devices more powerful than any smartphone now in existence. They will be able to tap into an almost free stream of knowledge and entertainment that, for some, will effectively merge the physical and virtual worlds. The persistence of youth unemployment coupled with an understanding of what they are missing will produce a rise in radical political and religious groups across Africa, of which Boko Haram in northern Nigeria can be seen as both proof and forewarning. Other elements will exacerbate this general insecurity, including widespread mental and physical stunting as a result of childhood malnutrition and the depressive economic effects of hopelessness. To this should be added the risks caused by soil exhaustion and desertification, the dying off insects necessary for pollination, and the possible effects of climate change on food security.

This is not an argument for neo-Malthusianism. Nothing has yet been decided. The cities new Africans will inhabit have yet to be built. On the contrary, Africa is rich. It harbours treasures of food,

water and minerals. It has more genetic diversity of our own and other species than anywhere else on the planet. It is the mother continent. Our hominid line extends back 3.2 million years in Africa. Our mitochondrial DNA appears to converge on a single woman who lived on the African savannah 150,000 years ago. Our Y-chromosome survives from a man who lived in the Rift Valley of Kenya or Tanzania 59,000 years ago. Freud just scratched the surface: our sense of light and dark, fear and lust grew within us in Africa. It is central to the past and future of our species.



Icarus.

Africa is coming online when new technologies are coming online. As fast as Africa grows, robotics will grow still faster. The planetary application of advanced technology will necessarily reach Africa and empower it: 2060 is also the year for the Project Icarus group plan to launch the first interstellar spacecraft — probably from a launchpad in Africa. If we recalibrate donkeys according to the ambitions of Icarus, they look to be modest and self-explanatory. Conventional development narratives, written as a litany, but lacking much sense of urgency, will be outflanked by events and innovations.

A Future without Roads

A further reason for going to the lower sky is the certainty that there isn't going to be enough cash for Africa to build out its roads. Africa's road network is sparse, reflecting both the newness of place and the utter failure of colonial and post-colonial rule, which was conceived for export of the treasure to richer markets, hardly taking into account the desire of a community to trade over the next hill. Africa is vast.



There is still no road connecting its east and west. By some estimates, an hour's travel in Congo at independence in 1960 is the equivalent of a day's travel today. The continent cannot speak to itself economically: only 15% of trade is interAfrican. Donkeys will call the bluff of governments committed to regional free trade by overflying borders. Although there will be contraband, thieving, the tracking of donkey cargo will be more transparent and the tax revenues more certain than road transport.

The only conceivable strong future for Africa is a sharing economy, where goods are used multiple times, in multiple ways. In order to share, you need to move around people, exabytes of data, and cargo. Africa does a terrible job at all three. Digital connectivity will be solved because it is affordable and in the interests of big technology companies. Moving around people and physical stuff will require massive upgrading of roads. By some counts, only 16% of African roads are paved

and many of those are quickly broken open by heavy traffic. Most Africans have to walk to reach any kind of engineered road. Mostly, these will be graded dirt roads that turn to mud during the twice yearly rainy seasons. In some countries, whole districts are cut off for weeks by flooding, mudslides, and wallows deep enough to sink a lorry to its axle. Although China will build more motorways and direct taxation on petrol can bring in significant revenues for road building, simply maintaining Africa's existing roads will be problematic. Africa's shortfall on annual public infrastructure spending is \$50 billion and rising. There is no money for tunnels and not enough for bridges and bypasses. Paving secondary roads is more expensive per kilometre than paving longer arterial roads and costs have risen sharply in the last decade, with frequent budget overruns of 100% or more. Economists have estimated that \$1 spent on roads in Africa returns \$4 in productivity. How much better value would \$1 spent on cargo drone routes be?

Fear of drones falling out of the sky should be set against the carnage on African roads. Donkeys can save lives by flying instead of driving. Admittedly, this is a somewhat cold and actuarial argument, since it is likely that persons will eventually be killed by falling, skidding, exploding drones. Nevertheless, deaths from transporting the same goods by drone will be fractional compared to roads. Death by motor vehicle is the third highest cause of death in Africa after malaria and HIV-Aids. The continent has 2% of the world's motor vehicles, but accounts for 16% of world road deaths. A study showed that 74% of hospital admissions for traffic injuries in Uganda in 2011 were of children under the age of 13, most of them hit by passing motor vehicles.

The Killer App is Repetition

I have identified 80 kilometre routes in Tanzania, Uganda, and Rwanda. Other prospective countries for early routes are Angola, Zambia, Ethiopia, Kenya, Namibia and South Africa. Routes can be tacked together to extend range. By way of example, it is possible in Rwanda to set up a donkey route from the town of Gitarama over the Nyungwe forest to Lake Kivu and down to the Congolese city of Bukavu. A country as compact and hilly as Rwanda can quickly draw routes across its lower sky and intersect them to most improve health and economic outcomes. My future Africa initiative at EPFL will get the first route up and running. An associated fund based in Africa and Switzerland will push for world-class research on the robotics, engineering, logistics, and law related to donkeys. It will also push for the establishment of an international agency for the lower sky, which will set global norms for the use of donkeys and other civilian drones.

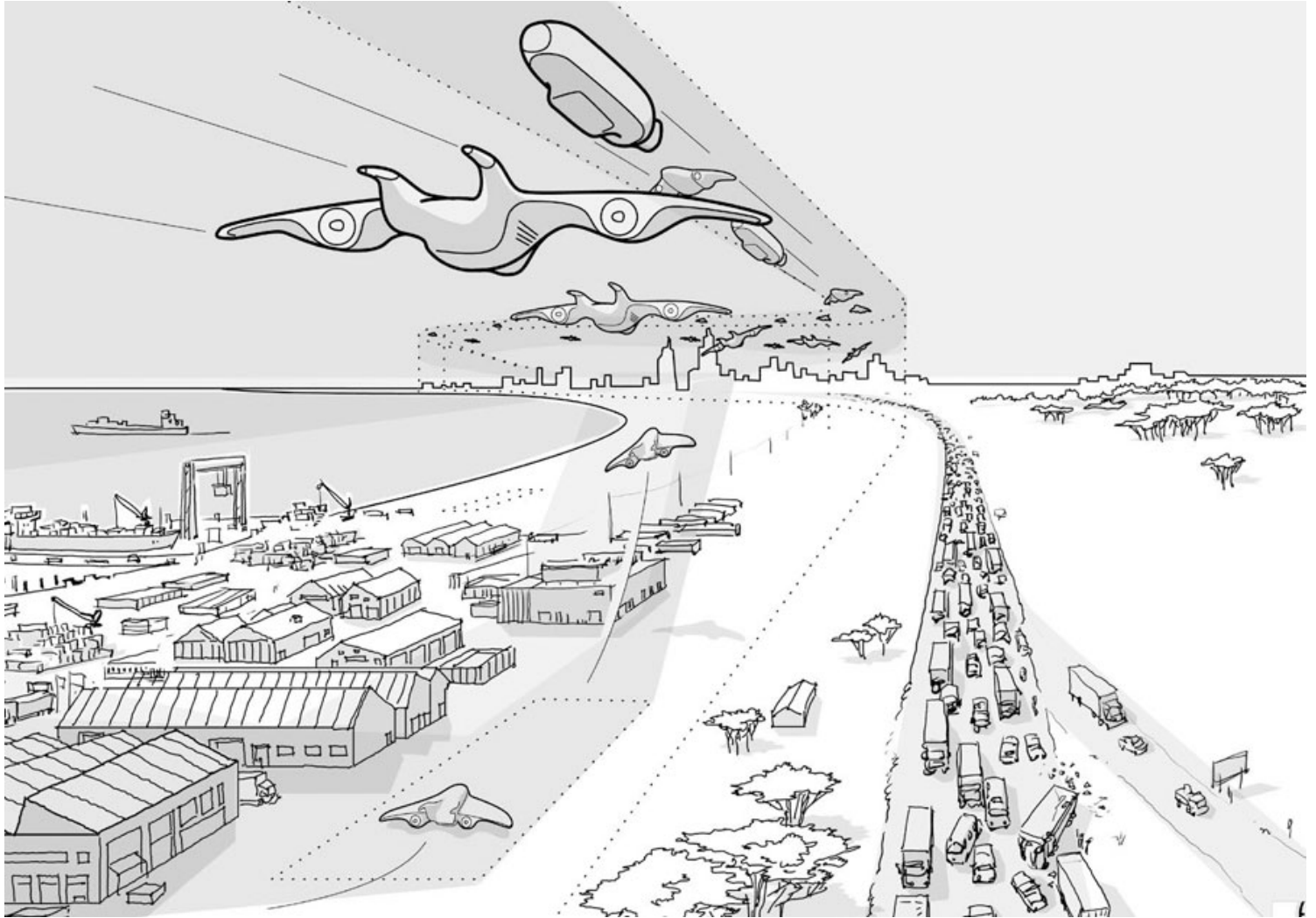
I anticipate three phases to the technology. In Phase 1, starting in 2016, drones will serve hospitals and humanitarian emergencies — life air not prime air. Other early adopters will use donkeys to deliver small payloads to government offices, mines, oil and gas installations, ranches and conservancies. In Phase 2, industrial sweetspots to cities such as the spare parts industry in southeast Nigeria will be connected to cities by donkey routes— just as the Liverpool and Manchester railway connected the first city of the industrial age with the Atlantic. These routes will serve the new solutions demanded by a sharing economy, such as where customers opt for rental and servicing of machinery rather than outright purchase. Companies of building and mining equipment will stock their large inventory of spare parts using donkeys carrying 10 kilo payloads. Phase 1 and 2 would be enough to make the donkeys a useful contributor. But the real reason for the technology is Phase 3, where donkeys will better connect businesses with customers right across Africa.

Donkeys will help small companies to grow through e-commerce. Wherever you have impecunious young people ubiquitously connected to the internet, e-commerce is desperate to happen. And this is even more true in Africa where, for various reasons, the retail high street will never be built out, and where existing sales of electronics, appliances and most other imported goods are dominated by supermarkets with limited stocks and high margins. Donkeys can extend the range of e-commerce outside big cities. In its recent appeal to the US Federal Aviation Authority for airspace in Washington State to test the latest iteration of the Prime Air drones, Amazon stated that 86% of the packages it delivers weigh less than 2.3 kilos. While the instant gratification and last mile delivery proposed by Amazon is not as relevant in poorer countries, the coupling of drones with warehouses is. Within a decade, donkey stations will have shops where staff talk customers through shopping options on tablets and goods are shipped by donkey from a distant warehouse within minutes. In effect, the back room of the village shop will stretch out of sight, with unbounded choice, and low prices . All of this is possible because the donkey has a killer app. It is not going clear across the lower sky. The killer app is repetition. A donkey can make many journeys in a day and through the night. The most populated bit of Africa is Equatorial. Every day is the same length, and every night. Donkeys will fly in the 12 hours of dark, hyena time, pothole time, where not many lorries venture out — gliding through the hot night, hushed, blinking green, delivering fresh for the new day. With 9 billion humans soon to be alive and divvying up our limited planetary resources, unmanned flight is inevitable.

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Cargo Drones design by S. Shiraishi.

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Norway and Saudi Arabia. But the biggest opportunity is in Africa. Many people are going to save a lot of lives and make a lot of money by putting the donkey in the lower sky there first.

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