The Economist

Expanding the internet

Sky-Fi

A number of companies have bold ambitions to use satellites, drones and balloons to bring the internet to the unconnected

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EVER since the early 1990s, when it moved out of universities and was embraced by the general public, the internet has grown relentlessly. Only 2% of the world's population was online in 1997. By 2014 the proportion had risen to 39%, or about 3 billion people (see chart below). But that still leaves another 4 billion who live an internet-free existence.

Most of the bereft are in the developing world, where only 32% of people are online, compared with 78% in rich countries. And those numbers disguise plenty of local variation. Just 19% of people in Africa were internet users in 2014. Like most infrastructure, the internet is easiest to provide in cities. People scattered in the countryside—even those in rich countries—must often do without.

Yet that may be about to change. Four technology companies are pursuing ambitious plans that could, eventually, provide reasonably fast, high-quality connections to almost everyone on Earth. Google dreams of doing so with a globe-circling flock of helium balloons. Facebook's plan requires a fleet of solar-powered robotic aircraft, known as drones. And two firms—SpaceX, a rocket company, and OneWeb, a startup based in Florida—aim to use swarms of cheap, low-flying satellites. By providing an easy route to the internet at large, local telecoms firms should be able to provide high-speed, third- or fourth-generation mobile-phone coverage to areas far away from the big cities.

The top-down approach makes sense, for the familiar terrestrial technologies are not well-suited to covering the globe with lots of fast connections. Providing the sort of cabling common in rich cities to every home on Earth would be prohibitively expensive. Mobile-phone masts do away with much of the wiring, but the masts themselves still require "backhaul"—a high-bandwidth connection to the internet. As a result, fast mobile networks are far from ubiquitous even in rural parts of the rich world. They are almost unheard of in

poor-country villages.

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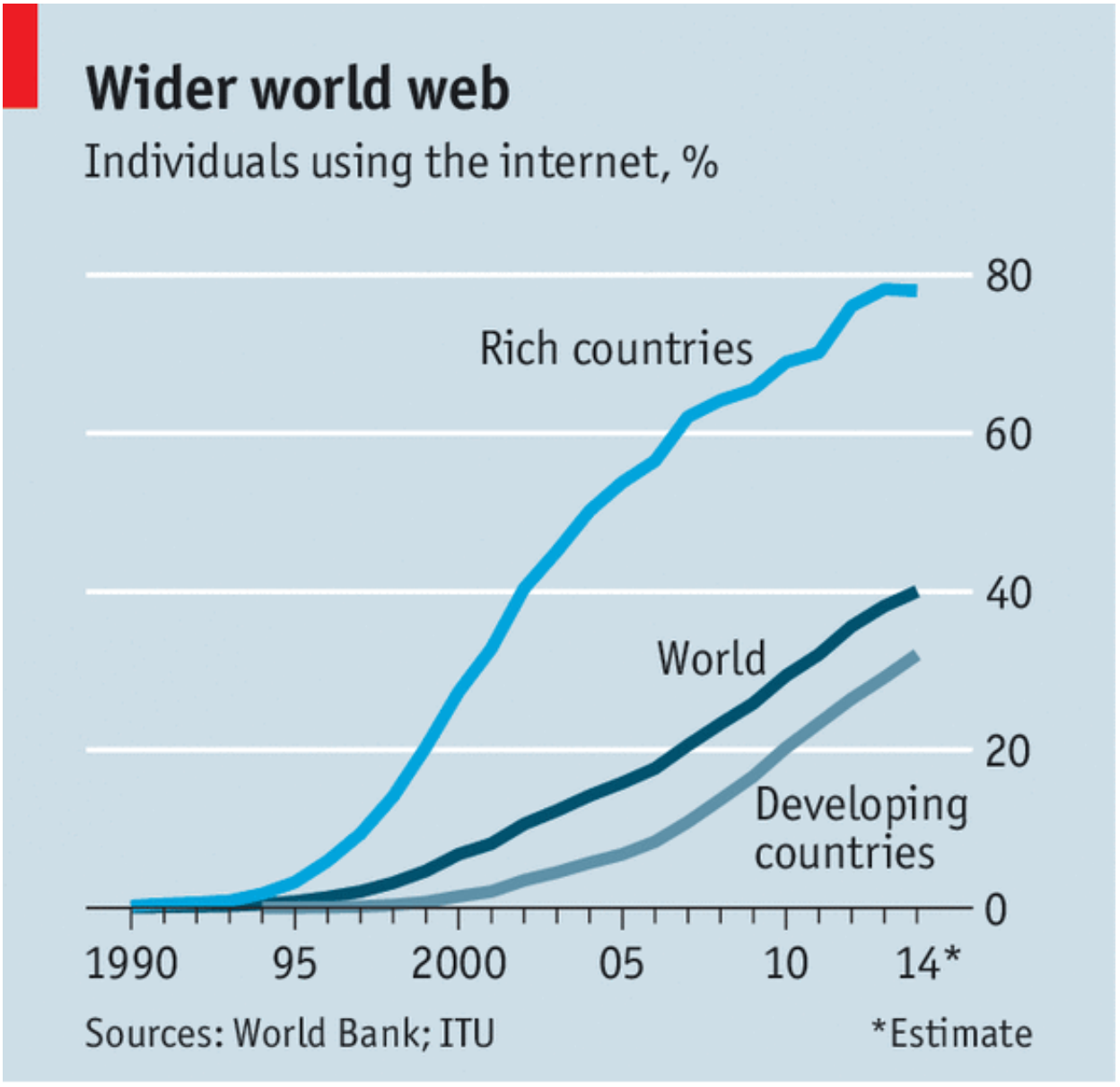

satellite, however, can see (and be seen from) huge chunks of the planet's surface. In theory, that allows the provision of data to millions of people at once. And satellite internet services are already widely available, but prices tend to be high, bandwidth limited and data allowances small. Many existing communications satellites fly in geostationary orbits, some 36,000km high, where they stay over a fixed point on the Earth's surface. This has two unavoidable drawbacks. The strength of a radio signal falls off rapidly with distance, so beefy transmitters and good power supplies are needed to contact them. The second problem is called latency, which is a delay in the signal. It can take at least half a second for a request for, say, a webpage to travel from the ground to the satellite and back down again, and then the page itself to make the same trip in reverse. That may not sound like much, but it is a tenth or less of the speed of a wired connection, even before other internet latencies. "No one uses a geostationary satellite and says 'I've solved my problem for ever,'" says Greg Wyler, the founder of OneWeb.

Lower they go

Mr Wyler's firm plans to launch 648 small, relatively simple satellites into much lower orbits of 1,200km. This will provide a latency similar to that offered by a fixed-line connection. And it will allow the use of much less-powerful aerials on the ground. OneWeb will offer its services to airlines and military customers, as well as emergency services and disaster-relief organisations, although it plans to attract individual customers, too, through deals with local telecoms firms. Because a single satellite will be able to provide backhaul to dozens of villages at a time, Mr Wyler hopes that local operators will be able to afford to build phone masts or internet base-stations in rural schools, village centres and the like. In the most remote areas, the masts might be powered by solar panels. Those who are still disconnected in the rich world could sign up, too.

But although low orbits offer much better latency, they are also more complicated. Unlike geostationary satellites, low-flying ones move relative to the ground, so hundreds of them would be required to provide reliable coverage across the entire planet. When one satellite disappears over the horizon, radio equipment on the ground needs swiftly to connect to another one in view without the user noticing (rather as mobile phones do when they move out of the range of one mast and into the range of another). Doing that successfully requires a lot of tricky signal processing, says Mr Wyler. It is only in recent years that aerials and chips have become so sophisticated and cheap enough to make such a system possible. OneWeb is helped in this by Qualcomm, an American firm that makes chips for mobile phones and has the necessary expertise—and is one of its early investors.

Mr Wyler is not alone in backing low-flying satellites. Elon Musk, a billionaire co-founder of PayPal whose firms now include Tesla, a maker of electric cars, and SpaceX, wants to do something similar. His constellation would orbit at a similar altitude, but the satellites would be slightly more sophisticated than the sort that Mr Wyler intends to fly. Besides providing the internet to the unconnected, they would serve another market, too. Mr Musk has pointed out that light travels more than 40% faster in space than it does inside a fibre-optic cable. His low-flying satellites could offer faster transmission of data over long distances than a cabled connection could on the ground. For time-sensitive information, such as that used in some financial trades where split seconds count, such a service might be highly appealing.

Mr Musk and Mr Wyler both seem to have the technical expertise to make these new satellite services a reality. One of Mr Wyler's existing firms, O3B, specialises in providing satellite-internet to oil rigs, cruise ships and other businesses with remote operations. OneWeb has already been granted a slice of precious radio spectrum in which to transmit its data (SpaceX has not, although there is a rumour that it hopes to work around this by communicating with lasers instead.) Mr Musk is an experienced disrupter of technological industries, and SpaceX's rockets offer some of the cheapest launch prices. With hundreds of satellites to put into orbit, that would keep his outgoings down.

Indeed, costs will ultimately determine whether such projects can be successful. SpaceX and OneWeb's potential customers in poor countries will not be able to pay much for their connections. Both firms hope to take advantage of cheap, off-the-shelf parts, rather than the expensive bespoke electronics typically employed in big satellites. Economies of scale should also help. OneWeb reckons its hundreds of satellites might cost just $350,000 each, with a total cost for the project of around $2 billion. Mr Musk's system could end up costing around $10 billion. Both will have to fight off competition from incumbent satellite operators such as Intelsat, which are busy launching new, more potent geostationary satellites.

There will also be rival technologies in the air. Yael Maguire, the engineering director of Facebook's Connectivity Lab, thinks that satellites are inherently inefficient: the world is 70% ocean, for one thing, so satellites will spend some of their time flying over places where no one lives. And even among poor countries, rudimentary connectivity is often available: about 85% of the world's population has access to at least a second-generation mobile-phone network, he says, which can provide limited access.

Send in the drones

So, rather than trying to provide global coverage, Facebook plans to plug specific gaps in the existing infrastructure. Despite its misgivings, it is investigating the use of satellites, as well as doing deals with mobile operators in poor countries to provide basic access to a small number of sites free for users of its Internet.org app. But Facebook's most ambitious project is for a fleet of solar-powered, propeller-driven drones that will fly at altitudes of 20km or more, which is well above the level used by commercial aviation, beaming an internet connection down to users on the ground.

The drones will be able to communicate with each other using lasers, relaying data until it can be passed to a ground station and on to the rest of the internet. The firm has already carried out flight tests in Britain, where its drones are built by Ascenta, a firm that Facebook bought for $20m in 2014.

Being solar-powered, the drones will be able to stay aloft for months at a time, coming down only for repairs and maintenance. That downtime offers another benefit: drones can be upgraded a lot more easily than a satellite, which, once launched, is stuck in space. Although their "footprint" of coverage will be much lower than even a low-orbiting satellite, drones can circle above one specific location that lacks connectivity. And, says Mr Maguire, launching a drone is always going to be cheaper than putting a satellite into orbit.

Google has also been experimenting with drones. But its chief idea is perhaps the simplest of all. "Project Loon"—so called because, when it was first suggested, the idea seemed crazy—is to gird the Earth with a swarm of thousands of helium-filled balloons. Each will carry a solar-powered wireless transmitter and, like Facebook's drones, will be capable of relaying traffic from other balloons. In contrast to the rival companies, which are mostly

concentrating on providing ways to deliver the internet to mobile-phone towers or Wi-Fi relays on the ground, Loon balloons may be used as flying base stations, capable of talking directly to mobile devices on the ground. In February 2014 the record duration for a flight was 50 days. Google's latest models are capable of remaining airborne for six months or more.

Unlike Facebook's drones, the balloons will not have engines. But that does not mean they cannot be steered. The winds in the stratosphere, where the balloons will fly, are, as the name suggests, stratified. The balloons will have the ability to change altitude, letting them hitch a ride on winds blowing in different directions at different speeds. A constantly updated computer model will keep track of each balloon, directing their trips around the world so that there will never—or only very rarely—be holes in the coverage.

By taking advantage of different wind speeds, the balloons should be able to minimise the time they spend over uninhabited areas, drifting in slow winds over populated areas while rising or falling into faster currents to speed them across oceans or deserts. "We have 30 years of wind-speed data to do this with," says Mike Cassidy, the man in charge of the project. And the balloons themselves will be able to measure wind speed, improving the ability of Google's computers to marshal them around the world (and giving the firm the most comprehensive set of wind data held by any organisation—which it has promised to share with weather forecasters and climatologists).

One day Google's balloon will go up

It all sounds grand on paper—perhaps too grand. The satellite projects, in particular, are not a new idea: in the late 1990s, during the heady days of the technology boom, several companies planned something similar, but none of their plans came to fruition. Yet the internet is a much more important part of the global economy now. The hope is that demand for the myriad services available online will continue to grow strongly, helping the business case.

Rules and regulations

Regulatory approval will also be crucial to the success of the projects. Facebook must contend with regulators in some countries that heavily restrict the use of drones. And Google will need to develop an infrastructure capable of launching and retrieving what could amount to hundreds of balloons a day. Satellites must be disposed of at the end of their lives,

whether by boosting them into a stable “graveyard” orbit or having them burn up in the atmosphere. Drones and balloons can crash, so safety regulators will need to be persuaded that the risks are acceptable.

The involvement of Google and, especially, Facebook, which run some of the most popular sites on the web, has caused some raised eyebrows. Facebook’s Internet.org app allows mobile-phone users to connect to the internet without incurring charges. But only a handful of websites can be visited, one of which is Facebook itself, raising concerns about attempts to lock customers in. Perhaps to allay such suspicions, Mr Maguire says that Facebook is considering making its drone designs available for anyone to copy, much as the firm did in 2011 with its designs for advanced computer servers.

The companies are optimistic that they will succeed in spreading the internet: all say that telecoms firms in poor countries are enthusiastic. SpaceX reckons its satellites will be ready in five years. OneWeb thinks it can open for business in 2019. Facebook will not specify a date, other than saying that its drones could start flying commercially “fairly soon”. And Google expects to begin commercial trials of its balloons next year. If any of them succeeds, then the idea of the internet as a “global village” will be more than just a quaint metaphor.

From the print edition: Science and technology