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News & Highlights

Signaling the Future, Cell Phones Gain Limited Satellite-Link Capabilities

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On 13 December 2022, a couple was driving through the Angeles National Forest near Los Angeles, CA, USA, when their car slid off the road, plowed 100 m down a steep hillside, and landed upside down at the bottom of a canyon [1]. Although the couple suffered only minor injuries, they were trapped in the canyon, and in the remote area the passenger could not get any reception on her iPhone 14 cellular phone. Still, she was able to send an SOS through a new feature on the phone that routes such messages via satellites [2]. Rescuers alerted to the couple's location airlifted them out of the canyon later the same day.

Apple's iPhone 14 was the first cell phone on the US market capable of transmitting to satellites, although users can only dispatch emergency alerts [2]. But a slew of other companies is rushing to offer satellite connectivity. This year, T-Mobile (Bellevue, WA, USA), the third largest US cell phone carrier, will start testing a service that will rely on Starlink satellites launched by SpaceX (Hawthorne, CA, USA) [3]. The start-up Lynk Global (Falls Church, VA, USA), has signed agreements with 25 mobile providers around the world and started launching its own satellites [4,5]. Other companies working on their own services or that have released satellite-enabled phones include giants like Amazon, AT&T, Verizon, and Huawei [5,6].

Like iPhone maker Apple (Cupertino, CA, USA), most of these companies will initially offer limited communication such as texting before eventually adding calling and broadband [5,7]. The market for satellite-enabled phones is small now—they are useful mainly for people who live in or travel to remote areas without conventional cell coverage. "If you live in a city and have no interest in climbing mountains, you would rarely use it," said Jon Peha, professor of engineering and public policy at Carnegie Mellon University in Pittsburgh, PA, USA. But that will change as more companies begin offering satellite connectivity and it begins to catch up to traditional cellular in quality and cost, said Rob Enderle, an industry analyst based in Bend, OR, USA. Satellites capable of transmitting voice and broadband "will be common by the end of the decade," and will eventually become the predominant type of cell service, he said.

Satellite phones, which allow users without cell service to make calls and send texts or short e-mails, have been around for more than 20 years (Fig. 1). But these devices were never practical for the general public for several reasons, including high usage costs of up to 10 USD per minute [8] and data transmission rates, as one writer described it, "like an old modem connection, only worse" [9].

(a) (b)

Fig. 1. (a) Like many other satellite phones, the one being used by this US soldier requires an external antenna to get a signal. (b) One reason satellite phones never caught on with consumers is their ergonomics, as exemplified by the ungainly antenna on the model shown here. Credit: (a) US Navy (public domain); (b) Bruno Sanchez-Andrade Nuño (CC BY 2.0).

Improved satellite technology has made communicating with cell phones easier. Because satellites are now smaller and cheaper than ever, companies can launch more of them and position them in low-earth orbit (LEO), where relatively weak signals from cell phones can more easily reach them [5]. In addition, cell phones in different countries often rely on different frequencies, and satellites used to need specialized hardware so they could adjust the frequencies they send and receive as they orbit [5]. Now, satellites feature software-defined radios, systems that can digitally perform this frequency hopping adjustment [5].

Most of today's cell phones only have to exchange data with Wi-Fi networks or with towers that are typically less than 10 km distant, not with satellites that are thousands of kilometers above Earth [10]. However, manufacturers have started incorporating new microchips into their designs to create stronger links with satellites. Apple's iPhone 14, for instance, contains a modem chip from San Diego, CA, USA-based chipmaker Qualcomm that can communicate with satellites in the n53 band of the frequency spectrum, which spans 2483 to 2495 MHz [11]. In 2023, some high-end Android phones will also begin delivering satellite connectivity through two other Qualcomm chips [12]. But new phones may not be necessary for some users. T-Mobile claims its service

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will work with existing 5G phones and even some earlier models [13].

What the companies racing to provide satellite connectivity will deliver depends on their technology choices. Apple partnered with Globalstar, headquartered in Covington, LA, USA, which already operated a network of 24 satellites used by satellite phones [14]. Thus, Apple did not have to launch new satellites to debut its emergency messaging feature. However, the satellite phones that communicate through the Globalstar network sport a large antenna that the iPhone lacks [15]. To make a connection, iPhone users in a dire situation must point the phone at the satellite—a compass-like guide on the display helps them aim (Fig. 2)—and may have to wait more than 10 min to get a signal [5,15]. Users also cannot send customized messages. Instead, they choose from menus of options. For the type of emergency, for example, the choices include "fire," "vehicle situation," and "crime" [15].

Globalstar's satellites are in LEO about 1400 km above the surface, and most companies also intend to stick to similar altitudes for their satellites. The Bullitt Group, located in Reading, UK, took a different approach, however. In February, it announced new satellite-enabled Android smartphones that permit two-way texting through a constellation of satellites in geosynchronous orbit more than 35 000 km above the Earth [16]. Like Apple, Bullitt piggybacked on an existing satellite constellation used for satellite phones. The transmission delay for satellites in geosynchronous orbit is much longer than for satellites in LEO—texts from Bullitt phones require about 10 s to reach recipients [16,17]. But if a service only provides texting capability, that delay is not a drawback. "If it takes a few seconds to send a text, you do not care," said Peha.

Most companies plan to go beyond mere texting, however, and a 10 s delay "will not work" for calls or broadband, said Peha. For a user to make a satellite cell phone call, not only must satellites be close to Earth, but at least one satellite in the constellation must be overhead at all times, he said. Thus, companies will need large numbers of satellites to ensure that at least one is always in range, Peha added. The launches have already started. Lynk Global, which sent up its first satellite last year, plans to have over 5000 more in space by 2027 [5]. SpaceX, which already boasts more than 4000 satellites in LEO [18], has begun deploying new satellites outfitted with more powerful antennas that are better able to receive cell phone transmissions [19]. AST SpaceMobile, headquartered in Midland, TX, USA, is going for size rather than numbers. Its satellites will carry enormous 63 m^2 antennas that the company claims will provide 5G connectivity from space [20].

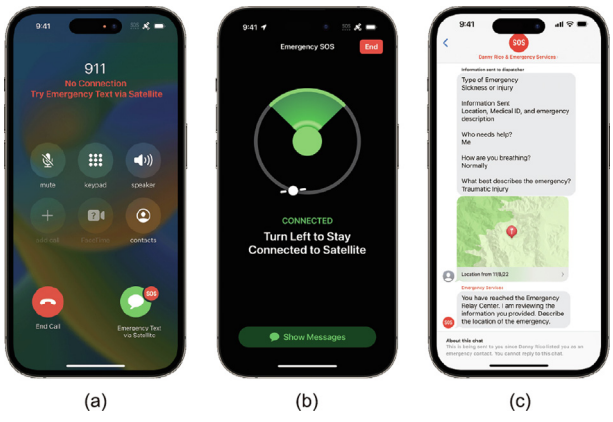

Fig. 2. The satellite-linked emergency alert system on the iPhone 14 allows users to send a request for help. (a) The system kicks in when there is no cell service to make a 911 call. (b) One of its features is a guide that helps the user aim the phone at the appropriate satellite. (c) While the system generates prompts to help users specify their type of emergency, it cannot send customized messages. Credit: Apple Inc. (public domain).

Customers who decide to try the new "Cell-Sat" phones will find some downsides. Transmitting data via satellites "is expensive, and the amount of bandwidth you can take up is limited," said Enderle. For instance, according to the Bullitt website, a plan that allows users with its phone to send 30 texts a month costs 4.99 EUR [16]. Whether consumers will pay extra to use such services and to obtain satellite-enabled devices remains uncertain. However, said Peha, "we are already seeing companies figure out how to put this capability into consumer phones at a reasonably low cost."

Carriers' increasing reliance on satellite-based networks could also create or worsen some problems. The proliferation of satellites and services blasting out cell signals might exacerbate conflicts over how to parcel out the frequency spectrum. The cell phone carrier AT&T has asked the US Federal Communications Commission to halt T-Mobile's plan to provide cell service through Starlink satellites, arguing that the transmissions would interfere with ground-based networks [21]. Divvying up the spectrum "is getting increasingly complicated, so we need to figure out how to do this intelligently," said Peha. Existing satellites are already disrupting astronomical observations [22], and the thousands more that companies plan to launch in the next few years will make it harder for astronomers to get a clear view. They have already complained about the brightness of AST SpaceMobile's prototype satellite, launched in 2022 [23]. And when these satellites go out of service, they will increase the sizable amount of space trash in orbit that already threatens other satellites and spacecraft [24].

Still, consumers will likely have several satellite cell phone options soon. Users who already have good service will not be tempted—it would be "a step back" for them, said Enderle. But for people in rural areas and elsewhere who currently get weak or no cell service, a satellite linked phone could provide a welcome option. And as companies improve their offerings, more and more consumers are likely to switch, deciding that "they do not want to be without" this capability, said Peha. According to Enderle, satellite cell phone service will ultimately replace today's networks of wireless towers that relay cellphone signals, sparing carriers the expense and trouble of installing and maintaining this ground-based infrastructure. "We are on that path," he said.

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