INGRID BURRINGTON

NETWORKS of NEW YORK

AN ILLUSTRATED FIELD GUIDE TO URBAN INTERNET INFRASTRUCTURE

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INTRODUCTION

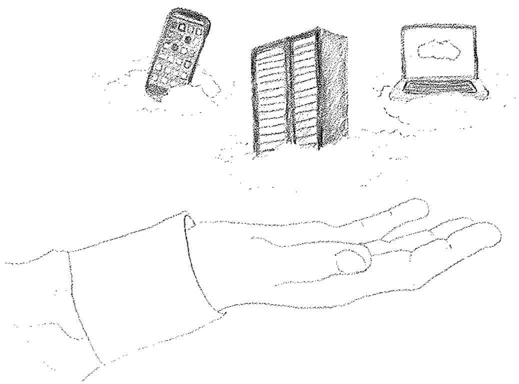
"How do you see the Internet?"

Over the past two years, I've asked a lot of people this question. It's a question often met with confusion or requests for clarification. Do I mean "What do you *think* about the Internet, like in the grand scheme of things?" or "How do you think the Internet *works?*" or "How do you *access* the Internet?" Really, I'm asking all three.

Sometimes it helps to start with that last question: how people access or use the Internet. For most people, the answer is that they see the Internet through screens—browsers and apps on laptops and phones. Sometimes people will point at a router, vaguely understanding that's the device their Wi-Fi connection comes from.

Once I understand the specifics of how someone interfaces with the Internet, I'll ask the second question: "How do you think the Internet works, and how do you visualize that process?" At this, answers vary, though they tend to follow three common trajectories, each one aligning well to certain tropes seen in stock photos and illustrations sometimes used to describe "the Internet."

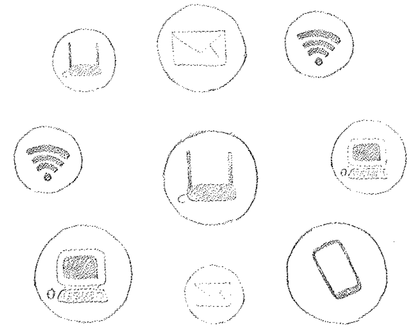
"I have no idea. Maybe black magic."



This answer sometimes involves hand-waving and anxious, slightly apologetic faces. To be fair, there are a lot of bad stock images out there that support that answer—which is to say, they make the mechanisms of the Internet appear impossibly complicated and opaque. You may have seen these sorts of images. Sometimes it's a man at the peak of an over-Photoshopped mountain, his arms reaching for a giant laptop in the sky from which fluffy white clouds emerge. Other times, it's a different man (always men in these weird dreamscapes, usually wearing ties), hands cradling poorly rendered collages of computers and a globe floating in some ethereal mist that could be data traveling across the network—or could be fairies, no one really knows.

Ironically, some of these baffling images emerge from attempts to make the Internet seem *less* complicated, through metaphors like "the cloud." Metaphors can be useful teaching tools, but when *all* that people know about the Internet are metaphors, it tends to make their understanding of it more clouded, not less.

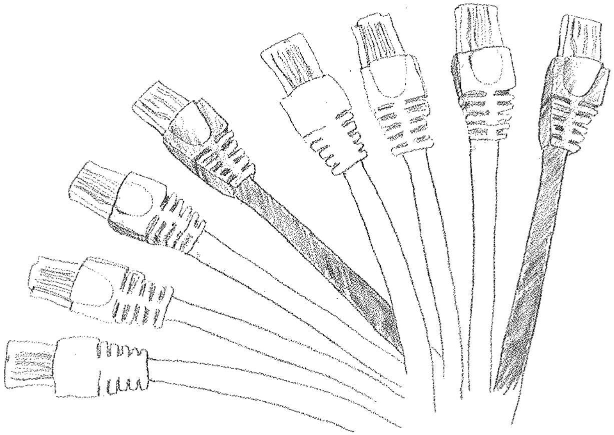
"It's a network of computers talking to computers."



This is the most pragmatic answer, and it's the one accompanied by stock images of network diagrams—icons of computers in dots, connected to one another with lines in an ever-expanding web. And it's slightly more accurate, but it's still an abstraction. It doesn't really convey the scale of the network, the volume of objects that are part of it, or the places where nodes in that network end up being concentrated. In reality, the Internet isn't an evenly distributed utility—nodes aren't all perfectly connected, and the quality of a connection can vary widely. While abstract network diagrams are good for getting a general idea of how it's supposed to work, they sweep up the particularities of geography and history that play a large role in shaping the Internet.

"There's a whole bunch of . . . computers somewhere doing . . . stuff. Cyber stuff."

We're getting warmer with this answer. There's actual reference to *objects*. We don't necessarily understand what they're *doing*, and maybe don't understand how they work



together, but they *exist*. The visuals associated with this answer tend to be extreme close-ups of cables and Ethernet ports or wide shots of dark hallways of server racks, illuminated only by the softly pulsing blue LED lights of machines. Rooms of wall-to-wall screens with incomprehensible diagrams or CCTV footage streaming across them.

There's an implicit assumption in these images that the Internet's physical spaces are privileged spaces, behind locked doors with retina scanners and high gates. These security procedures make sense, but the theater and optics that surround them encourage an assumption that only an elite few are clever and privileged enough to understand how the Internet actually works—and if you aren't one of those people, being curious about how the Internet works is circumspect.

The thing is, all of these answers—that the Internet is made up of objects, that it's a network, that it's weird black magic—are kind of correct. The magic part isn't necessarily how the machines work but rather the weird,

amazing, terrifying, and wonderful things that people figure out how to do with the network.

These notions of how the Internet works, and the images that illustrate them, are how I saw the Internet two years ago when I started asking people that annoying question. I didn't really know what the Internet looked like, but I was pretty sure it didn't look like any of the images I saw paired with headlines about Edward Snowden or Facebook or Google. I wanted to know about the stuff that made the Internet work, where it lived, and how I could find it. There are some excellent public resources on this topic, but for some questions I really wanted to talk to someone on the inside. However, with a few exceptions, almost everyone "official" I tried to talk to brushed me off. The rejections didn't read as a matter of security or of protecting the networks but more like a failed transaction. I wasn't specialized, I wasn't already an expert, I wasn't well connected, and I couldn't get anyone good press with my work. I was just some curious artist, so nobody really had any interest in answering my questions. I had to find the Internet on my own, starting where I already was: New York City, a weird set of islands off the coast of America.

This is how I find the Internet, now that it's been two years since I started looking: I go for a walk literally anywhere in the city. In the span of about three city blocks, I can usually figure out where there's buried fiber optic cable (and, sometimes, who owns that cable), which devices hanging above traffic intersections are talking to one another, how many cell towers are in the area, and whether I'm currently under surveillance (by the NYPD or a private observer).

When I do this, I don't have a cool gadget that shows me radio frequencies moving through the air or some kind of Internet divining rod. I have no secret expertise or ninja hacker skills. I'm just looking down at the ground and looking up at buildings. That's it. To me, this is another kind of Internet magic—maybe a more practical magic, the kind that recognizes the existence of things larger than oneself and one's small worldview. It's weirdly comforting, inspiring even, to walk down Sixth Avenue with the knowledge that buried underneath my feet is a fiber optic cable that is carrying conversations, photographs, stories, secrets, and *lives* as beams of light through hair-thin strands of glass. *Networks of New York* is a guide for practicing the everyday magic of seeing the Internet as part of a city's landscape and everyday life.

It's also a guide to some of the weird history and politics that shape how the Internet weaves its way through the city. In the United States, communications networks tend to be built on top of existing networks—fiber optic cable routes follow telephone routes, which in turn follow telegraph routes. This makes a lot of sense—it's easier to build on top of systems that already work than to start entirely from scratch. But it means that in especially old American cities (like New York, Chicago, San Francisco), the city's networks exist atop the sediment of past technologies. It's why buildings once crucial to the telegraph system are now home to hundreds of thousands of miles of fiber optic cable, and why those buildings' rooftops are now adorned with satellite receivers and microwave antennae.

Networks also tend to inherit the legacies of past networks in the same way that they inherit landscape. With each further compression of time and space through communications technologies, there's a lot of hopeful zeal that this will be society's turning point—that as radio waves and cables connect us across greater and greater distances, people will be closer, with greater freedom and greater choice than ever before. But that hopeful promise associated with an expanding Internet depends on equal access to it, and as examples in this field guide demonstrate, network access isn't necessarily evenly distributed to everyone. When the Internet is mostly owned by private companies, there's little financial incentive to treat it as a public right. The increasing presence and complexity of surveillance systems throughout cities also mean that networked technologies limit freedom as much as they enable it, and in places like New York, those systems tend to specifically observe and target minority populations.

New York's networks and the politics of those networks in some ways reflect very local concerns. Banks fighting for server space in data centers to shave microseconds off a financial transaction isn't necessarily every American city's Internet story. But some of New York's Internet stories—private companies monopolizing consumer Internet access, post-9/11 surveillance boondoggles, and a growing enthusiasm for data-driven cities leading to more networked sensors and objects in public space—do translate to the concerns and infrastructures of other cities. And while some of the specific companies and types of sensors and cameras mentioned in this field guide are distinct to New York, the *types* of objects documented (manhole covers, excavation markings, antennae, cameras) can be found in pretty much any American city. It's actually one of my favorite parts of visiting different U.S. cities. While some people seek out local cuisine or important landmarks, I get excited over spotting interesting telecom manhole covers.

One of the hardest parts of trying to see the Internet, of trying to even answer the question of how you see the Internet, is scale. The writer Quinn Norton has written about the difficulty of telling stories today in "a world where falling in love, going to war and filling out tax forms looks the same; it looks like typing." There is an unexpected intimacy to living with screens, but that intimacy does not typically extend to the cables and conduits the screens rely upon. As the division between "real life" and "online life" is increasingly understood to be a fiction (i.e., what people say and do online has real-world consequences, retweets are not endorsements, your boss can find your Tinder profile), the Internet's landscapes continue to appear at a remove from those physical landscapes in which we fall in love, go to war, and fill out tax forms. Ironically, the reason we can even have those weirdly personal moments with machines is because the landscapes of the Internet are folded into the landscapes of everyday life. We basically live inside a really big computer.

This is not an exaggeration. To understand this point, it's helpful to look at how people used to live with computers. When discussing this topic, the artist James Bridle often cites a quote from mathematician Harry Reed about the Electronic Numerical Integrator And Computer (ENIAC), one of the first modern computers, created during World War II: "The ENIAC itself, strangely, was a very personal computer. Now we think of a personal computer as one which you carry around with you. The ENIAC was actually one that you kind of lived inside."

While the hardware that we use to connect with one another has gotten a lot smaller, I don't think that computers have really become smaller since the days of the ENIAC. It's more that the room has just gotten bigger. It's not really a room so much as it's a planet. What we think of as personal computers today are just bits of aggregate hardware in a much larger, more complicated computer that is the Internet. But living inside a computer doesn't look like a cool science fiction movie or any of the stock images used to describe the Internet. It looks like cities, highways, buildings, and the infrastructure that supports them.

Infrastructure is the stuff of cities that only really gets noticed when it stops working. It's not so much invisible

as it is hard to see; it hides in plain sight. The trick of how to see the Internet isn't tech know-how or gaining access to secret rooms. It's learning what to look for and how to look for it. Learning how to see and pay attention to the fragmented indicators and nodes of networks on any city street is also a process of learning how to see and live within a world full of large, complicated systems. These systems often feel at a far remove from everyday life but frequently (and, in the case of the Internet, increasingly) shape and transform it. Hopefully this field guide will help you navigate those systems as much as it will help you navigate New York City.

BELOW THE GROUND

When trying to find Internet infrastructure in a city, it's helpful to start from the ground up—or, more precisely, somewhere just below the ground up, under manhole covers, inside underground ducts, and even farther below on subway platforms. Because getting online today usually involves connecting to a wireless network, it can be easy to forget that most of the Internet is, in fact, a series of tubes; wireless connections still have to go through wires. For example, when you use a Wi-Fi network in a public library, your Internet activity travels wirelessly to a router. That router is wired into a cable network, usually with an Ethernet cable. And that cable sends your Internet activity back into a global network made mostly of fiber optic cable. At the end of the day, most of the things we read and do online are reduced to pulses of light in glass tubes. And in New York, many of those glass tubes are *just underneath your feet*!

Despite being so close beneath our feet, it's not exactly easy to find those glass tubes. They're mostly buried. Internet cables in New York live in utility ducts, which are owned and maintained by three companies, Empire City Subway (ECS; no relation to the transportation subway system), Verizon New York, and Consolidated Edison Company of New York (also known as Con Ed, the local power company). Different companies own cables (copper, coaxial, or fiber) that run through these ducts. To run cables in the ducts, companies need to acquire a franchise from the city's Department of Information Technology and Telecommunications (DoITT). The agreements stipulate that the companies pay the city a percentage of their revenues in New York City, and that the company has to provide an amount of dedicated fiber to the city.

It's pretty hard to find a telecommunications company or city utility company that will just give you a map of where all the fiber optic cables are located. Usually the rationale for this is security, but it's

also because private companies view their networks as essentially proprietary business information, i.e., trade secrets. Still, it's possible to find the Internet under your feet without the aid of corporate maps—it's mostly a matter of knowing what to look for.

STREET MARKINGS

Sometimes while walking in a city, you might notice colorful markings on the street—neon arrows and labels, usually barely legible. The markings extend throughout the street, sometimes in zigzagging directions. This urban markdown language isn't really intended for people on the street. Whenever a contractor or construction company plans to do street excavation, they have to call 811, the nationwide number for utility-locating services. The contractor gives 811 information on where they'll be excavating, and 811 in turn contacts local utility companies—gas, electric, water, and telecom—to alert them that they need to mark out the location of their underground cables so that the contractor knows to watch out for them. In New York, people who locate utilities tend to use spray paint to mark out buried ducts; in more rural areas they'll sometimes use tiny flags or install signposts.

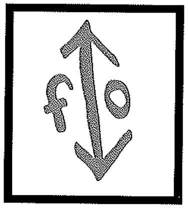
There's a standardized color code for street markings recommended by the American Public Works Association (APWA) and used by many cities, including New York (see inside back cover). Orange refers to the broad catch-all of "communications, alarm, signal lines, cables, and conduit." This means that orange lines represent Internet cables, television cables, or telephone lines—literal signs of the circulatory systems of the Internet and all the other networks around us.

These spray-painted markings aren't placed on the ground for the sake of a curious public but for construction crews, and their aesthetics reflect this target audience. They're often sloppily written with letters like "ECS" reduced to a single looping scribble. On rare occasions I've seen markings that include question marks, as if someone didn't entirely trust the map they used to locate buried utilities. The markings, like the construction sites they're created for, are also temporary. Depending on the weather, how much traffic crosses an intersection, and further excavation work, they fade away over the course of either a few months or a few weeks. Sometimes several different markings will cut across the same intersection, turning city streets into haphazard tapestries of excavation history.

While these markings aren't meant to be legible to the general public, they do offer a useful way of reverse engineering the locations of buried communications networks in a city. The level of detail about these networks that can be gleaned from the markings varies, as we'll see with the following examples—sometimes they indicate only that *some* kind of communications duct is underground, sometimes they indicate the type of cable underground, and sometimes they indicate what company owns that cable. The company names, however, can be a bit misleading—as we'll see, most telecommunications companies are not so much companies as they are chimeric creatures resulting from decades of companies forming, merging, and spinning off from or acquiring other companies. For the reader who might find the following histories of company mergers and acquisitions tedious, it is helpful to replace "company" with "dragon" and words like "acquired" with "devoured." It is not an inaccurate image for what mergers and acquisitions are really like.

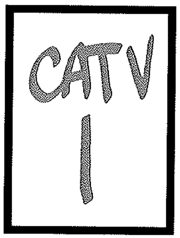
1. Types of Cable

FIBER OPTIC CABLE



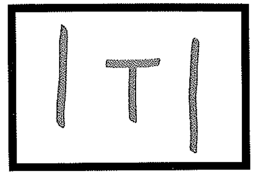
"Fiber optic" doesn't necessarily mean what's commonly thought of as the Internet—a variety of data types (Internet, video, voice communications) can run over a fiber optic cable. It also might not be part of what's considered the *public* Internet. Private companies sometimes maintain their own networks for internal communications, as do city agencies and universities.

CABLE TELEVISION



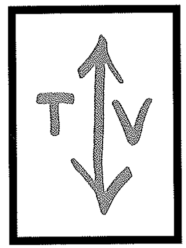
This means pretty much what you think it means: a cable for television, usually coaxial (for more, see page 98).

TELEPHONE LINES



Traditional land-line telephone connections are composed of two wires, historically made of copper, which run to the nearest telephone exchange building. While many have abandoned land lines for mobile phones and other online telephony services (known as Voice over Internet Protocol or VoIP), many land lines remain buried underground and in use.

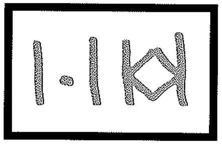
TELEVISION MARKING



This cable is more commonly seen in boroughs other than Manhattan, for reasons that remain unclear from field observation. Although the labeling indicates a television cable, most consumer Internet Service Providers (ISP) in New York operate as "bundlers" selling television, phone, and Internet connections in one package, and all three services are often transmitted along the same cables.

2. Characteristics of a Duct

DUCT WIDTH MARKINGS

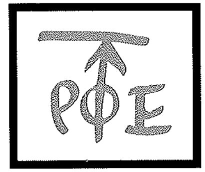


These markings, which may look like cave painting interpretations of TIE fighters in *Star Wars*, are standard markings approved by the APWA for marking the width of belowground ducts.

SHALLOW CABLE

This means basically what it sounds like: the underground cable isn't very deep under the pavement. This marking is a warning to anyone doing street excavation work that they might hit the cable. Another easy way to identify these shallowly buried ducts is to look at the road itself. Is the road a uniform color or does it have splotches of darker gray or black? Do the splotches run in uniform, parallel lines, about eighteen inches apart? These are most likely patches placed on the road after paving over a new, shallowly buried duct.

POINT OF ENTRY



This refers to the point at which a cable duct enters a building, typically entering at basement level. Usually these are seen at the edge of a building and not on the road itself.

3. Companies

EMPIRE CITY SUBWAY

Empire City Subway was formed in 1891 to construct and maintain tubes for telegraph and telephone cables ("subway" referred to anything underground, not just transportation networks) in Manhattan and the Bronx. Prior to that, all cables—communications and electric—were strung across the skyline on poles because it was cheaper for companies to keep adding cables above the ground than deal with the construction costs of putting them underground. Illustrations of Lower Manhattan in the 1880s depict the area under the shadow of densely layered cables, which sometimes snapped in wind- or snowstorms, lashing electric current through narrow city streets. It took the Great Blizzard of 1888 and the resulting massive property damage to finally push utility companies to bury cables underground.

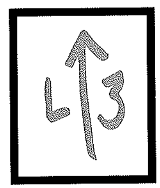
ECS operates only in Manhattan and the Bronx because in 1891 New York City was basically just those two boroughs. ECS now leases space in its conduits to telecommunications companies. They own approximately 11,000 manholes and 58 million feet of conduit. A marking that indicates "ECS" doesn't provide a ton of insight into the types of cables in a duct or who might own those cables; mostly it's just an indicator that *some* type of telecommunications network is in the area.

AT&T

AT&T has been a presence in New York City almost as long as telephones have have existed in New York City. The New York–based American Telephone and Telegraph Company was initially formed in 1885 by executives from Alexander Graham Bell's American Bell Telephone Company to create a nationwide long-distance network. AT&T first connected Chicago and New York in 1892 and then acquired American Bell, the company that technically created AT&T, in 1899. Corporate offspring devouring its parent company isn't that unusual an origin story, but it is unusual that in AT&T's case, it has happened more than once. After decades of holding a monopoly on the U.S. telecommunications industry, AT&T spun off its regional companies into seven separate entities in 1982 as part of an antitrust settlement with the U.S. Department of Justice. One of those spun-off companies, Southwest Bell, ended up growing to be one of the largest telecommunications companies in the United States, in part by taking advantage of changes to Federal Communications Commission rules in the mid-1990s. In 2005, what had been Southwest Bell (rebranded as SBC Communications in 1995) acquired AT&T and took on its parent company's branding.

While this field guide might not be the place for the entirety of AT&T and the Bell System's voluminous history, traces of that history can be found all over New York City. The company initially formed to create long-distance networks that would become known as AT&T's Long Lines division, and there are Long Lines switching stations and offices throughout Manhattan—a particularly Brutalist monstrosity at 33 Thomas Street, another switching center at 811 Tenth Avenue, and the former central Long Lines office at 32 Avenue of the Americas, which is now a major convergence and colocation center for networks.

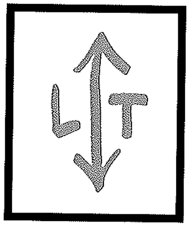
LEVEL 3 COMMUNICATIONS



Level 3 Communications began trading on NASDAQ in 1998 and received its franchise to build a fiber optic network in New York City in 1999. They are a major Tier 1 network, which means that their network has a direct

connection to every other network online without paying fees to do so—a process known in the telecom world as peering (for more on Level 3, see its Manhole Covers entry; for more on peering, see Glossary of Terms).

LIGHTOWER



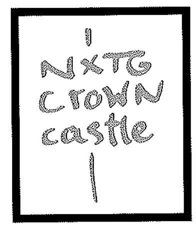
Emerging in 2006 from the ashes of what once was National Grid Wireless US, Lightower established itself as a purveyor of dark fiber (see Glossary of Terms) in New York City through a series of company acquisitions. Two of the crucial network expansions were in 2013, through a merger with Sidera Networks (formerly a part of the cable company RCN; for more, see RCN later in this section) and the acquisition of Lexent Metro Connect (formerly owned by the owners of Hugh O'Kane Electric, one of the most important cable splicing and fiber pulling companies in New York; for more, see Ground Level).

Lightower is majority owned by Berkshire Partners, a Boston-based private equity firm that has invested heavily in other telecommunications infrastructure companies, such as colocation services company Telx (for more on colocation, see Carrier Hotels in Ground Level), mobile infrastructure company Crown Castle International (for more, see Distributed Antenna Systems in Above Ground), and a variety of wireless antenna tower companies operating throughout the Americas and southeast Asia.

MCI

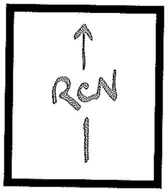
When the company began in 1963 with the intention of building out a microwave transmission network between Chicago and St. Louis, MCI stood for Microwave Communications, Inc. And like many entries in this field guide, it was devoured and transmogrified many times over by the dark alchemy of corporate mergers and acquisitions. Known as MCI WorldCom and later WorldCom between 1998 and 2003, the corporation reclaimed its original name following WorldCom's spectacular bankruptcy and corresponding financial scandals in 2002. While MCI as a company no longer exists (it was acquired by Verizon in 2006), its name has apparently not been completely phased out of use in network maps in New York.

NEXTG NETWORKS/CROWN CASTLE



In 2008, NextG Networks received a city franchise agreement to install wireless infrastructure on city street poles for its distributed antenna system (DAS—for more, see Distributed Antenna System in Ground Level). The agreement also permits the company to install fiber belowground "for purposes of connecting Base Stations installed on Street Poles to one another or to a supporting telecommunications system." These fiber markings are often found near street poles or at the bases of street poles. In 2011, NextG was acquired by mobile infrastructure company Crown Castle International. Both names tend to appear on their street markings, usually seen at the base of a street post with a DAS attached.

RCN



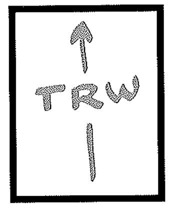
RCN is a major Internet service and television cable provider, but it's unclear whether a cable marked "RCN" is actually a cable that belongs to RCN or a cable that once belonged to a division of RCN. As many other examples in this field guide demonstrate, while cable networks change corporate parents and change names pretty frequently (particularly in the early 2000s), the maps used by utility locators aren't updated accordingly.

In 2001, Con Edison announced that they were creating their own fiber optic network, managed by the holding company Con Edison Communications. In 2006, RCN acquired Con Edison Communications for $32 million. Private equity firm ABRY Partners acquired RCN in 2010. The firm subsequently repackaged and rebranded its metro area operations (which managed the former Con Ed fiber network) as Sidera Networks. Sidera merged with Lightower Networks in 2013 (after both companies were acquired by Berkshire Partners in 2012). Both Lightower and RCN operate in New York, but given how many dated company names appear in sidewalk markings (see MCI), it's conceivable that an RCN marking is, in fact, now a Lightower cable.

SPRINT

Sprint, a company that emerged from the U.S. railroad network (Sprint is actually an acronym for Southern Pacific Railroad Internal Networking and Telephony), was one of the more forward-thinking telecommunications companies. It built the first nationwide fiber optic cable network in 1986. Today, the cables it runs throughout the city are primarily for network traffic on mobile phones (for more, see Cell Towers in Above Ground).

TRANSIT WIRELESS



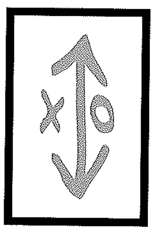
Transit Wireless provides wireless connectivity to the Metropolitan Transportation Authority's subway platforms (for more, see Subway Wireless Networks).

WINDSTREAM COMMUNICATIONS

While at the time of this writing, Windstream markings have only been sighted at 60 Hudson Street, a major

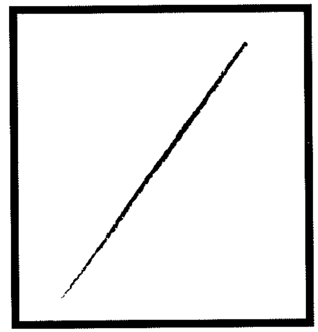
New York carrier hotel (for more, see Carrier Hotels in Ground Level), the Little Rock–based company is worth noting here due to a clever trick it pulled in the summer of 2014 that could reflect future patterns in telecommunications businesses. In 2014, the IRS and the U.S. Treasury expanded "eligible assets" for corporate entities known as real estate investment trusts (REIT) to include cables, transmission devices, and pipelines. Traditionally, REITs are companies that own or finance actual properties—houses, office buildings, land. The idea that infrastructure could constitute "property" in the same sense as a building is in and of itself philosophically interesting, and it also offers a useful financial loophole for companies that own a lot of infrastructure, since REITs are essentially tax-exempt entities. After the rule change went into effect, Windstream spun off its copper and fiber network into a REIT. The new REIT "leases" its property (i.e., the network) to Windstream for around $650 million, which Windstream can write off as a business expense. Basically, it is a way of funneling a lot of money away from taxes and into a black hole. Presumably Windstream markings in Lower Manhattan technically belong to this REIT.

XO COMMUNICATIONS



In 2002, like many network providers that built fiber optic networks in the mid-1990s, XO filed for bankruptcy. It emerged from bankruptcy in 2003 with well-known activist shareholder Carl Icahn as its majority shareholder and board chairman. In 2008, Icahn orchestrated a massive refinancing of XO's debt (90 percent of which Icahn owns) and took the company private in 2011. A lawsuit brought in 2009 by XO's minority shareholders, which accused Icahn of using XO's financial losses as tax benefits for other companies he owns, remains ongoing as of 2016.

MICROTRENCHING



Microtrenching is a technique for installing conduits into narrow "slot-cut" trenches in the ground. Currently the only fiber lines installed with microtrenching in New York City are owned by Verizon, who received a franchise for a microtrenching pilot program in 2013 as part of its franchise agreement to provide citywide fiber optic connectivity (for more, see Verizon sidebar).

Microtrenching involves less intensive excavation work to install than going deep into underground ducts, but only a limited number of fiber strands can be added and they are less protected from the elements. Signs of microtrenching resemble scars: places where it looks like narrow cuts have been made, and then repaired, on the street.

Verizon: The Infrastructural Elephant in the Room (or Really, in the Ducts)

While spray-paint markings or manhole covers for Verizon have yet to be sighted in the wild in New York, the telecommunications company has in many ways left its mark on the city's Internet infrastructure. Technically, it owns the majority of it. Verizon is the result of a 2000 merger between telecommunications giants GTE Corporation and Bell Atlantic, which included inheriting both Empire City Subway and the New York Telephone Company (now Verizon New York), the companies that own and maintain telecommunications ducts beneath New York City. In the past decade, however, Verizon has received more attention from the city for its often stalled efforts to implement new infrastructure, not for the infrastructure its subsidiaries maintain.

In 2008, Verizon entered into a franchise agreement with DoITT to build out an all-fiber network (branded Fios by Verizon) to serve all New York City residents with access to fiber optic cable connections. At the time, this was seen as a major opportunity to address the city's digital divides by bringing high-speed broadband to underserved areas still running connections across old coaxial or copper lines. According to the terms of the agreement, once a part of the Fios network "passed" (a distinction that will become relevant later) a building, that building's owner could request Fios service be installed, at which point Verizon would have a six-month window to do so. If Verizon's installation was obstructed, it would be required to explain the reason for the delay in writing and resolve the matter within another six months (a scenario called a "non-standard installation" or NSI). If Verizon was unable to bring fiber into a multiple-dwelling building (i.e., an apartment building), the company could petition the state Public Service Commission

for something called an Order of Entry Petition. Procedures for NSIs and multiple-dwelling units were written into the franchise agreement.

The contract required the company to "pass" all homes in every borough by the end of June 2014. While Verizon claimed in November 2014 that it had successfully "passed" all New York City households, as of 2016 many New Yorkers remain disconnected from Fios and unable to get it. An audit published by DoITT in June 2015 (based on limited access to Verizon's apparently very sloppy internal records) indicated that almost 75 percent of the NSIs outstanding at the time of the audit had been unresolved for longer than the twelve-month limit. While mostly anecdotal, reporting on the Fios rollout suggests that Verizon concentrated primarily on new developments and already wealthy or gentrifying neighborhoods, bypassing, and at times outright refusing, to provide service to other neighborhoods or buildings with no reason given.

Verizon and its lawyers argue that "connecting" was never the actual objective, leaning heavily on the fact that the original franchise agreement stated "passing" without having clarified if a cable passing a building has to be *accessible* to that building. They also argue that gaining access to multiple-dwelling units, dealing with landlords, and the costs and logistics of pulling new fiber into buildings is really, really hard. (Their response to DoITT's audit is a magnificent demonstration of the hypersensitivity of corporations to the conditions of reality.)

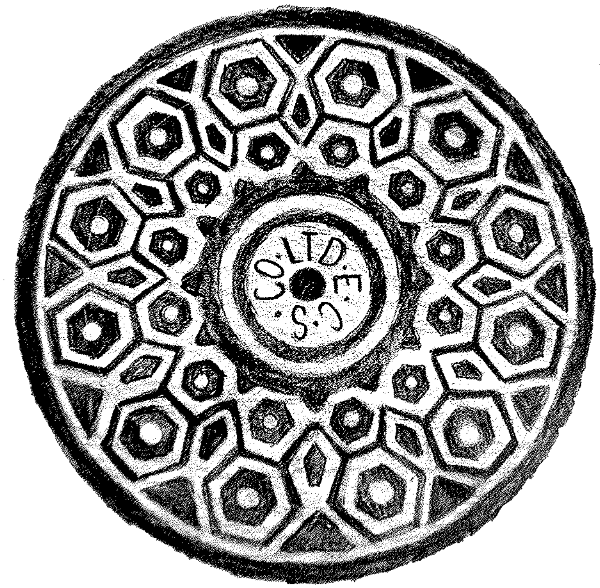
While this aside on Verizon's poorly implemented fiber network will admittedly quickly become dated, it's included as a reminder of the inherent obstacles to attempting city-wide connectivity improvements. But difficulties aside, Verizon has little incentive to negotiate these tricky, potentially low-return-on-investment installations. The franchise agreement doesn't significantly penalize Verizon for failing to meet its terms.

This isn't to say citywide fiber connectivity is impossible; other cities have done it. In Chattanooga, Tennessee, for example, the city's electric company EPB added a citywide gigabit fiber network parallel to the power grid. Since all Chattanooga households were already connected to the electricity network, the process of pulling in new fiber was far simpler than Verizon's debacle. But smaller cities can more easily get away with building out municipal Internet services. In larger cities like New York, where telecoms have very established footprints, private-sector solutions are typically favored over public ones.

MANHOLE COVERS AND HANDHOLES

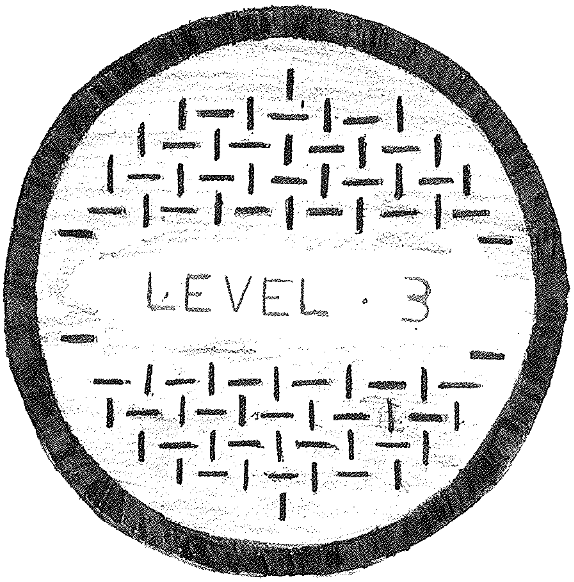
Once you've spent enough time looking for and at cable markings, you'll notice that the markings tend to go into or emerge from manholes on the street. Manhole covers are a literal point of entry into the city's underground world and their designs indicate what part of that world they connect to (e.g., the power grid, the gas system, or the telecommunications network). While the duct networks still belong to the aforementioned ECS, Verizon New York, and Con Edison, and most telecom duct manhole covers feature the same design, one aspect of having a franchise agreement in New York is that it entitles the franchise holder to install their own manholes and manhole covers in areas where they own a significant amount of cable.

EMPIRE CITY SUBWAY



The New York Telephone Company (also known as Bell Atlantic New York) was ECS's original primary shareholder, and the hexagonal pattern on ECS manhole covers can be seen in Brooklyn, Queens, and Staten Island with the Bell logo in the center rather than "ECS." Through the dissolution and reconstruction of what was the New York Telephone Company (for more, see Verizon sidebar), Verizon inherited all of its holdings, which means ECS is now a wholly owned subsidiary of Verizon. Verizon also maintains the ducts underneath the boroughs that ECS doesn't cover, under the subsidiary company Verizon New York. Manholes outside of ECS territory have the same hexagonal pattern but feature the old Bell logo instead of the ECS logo.

LEVEL 3 COMMUNICATIONS

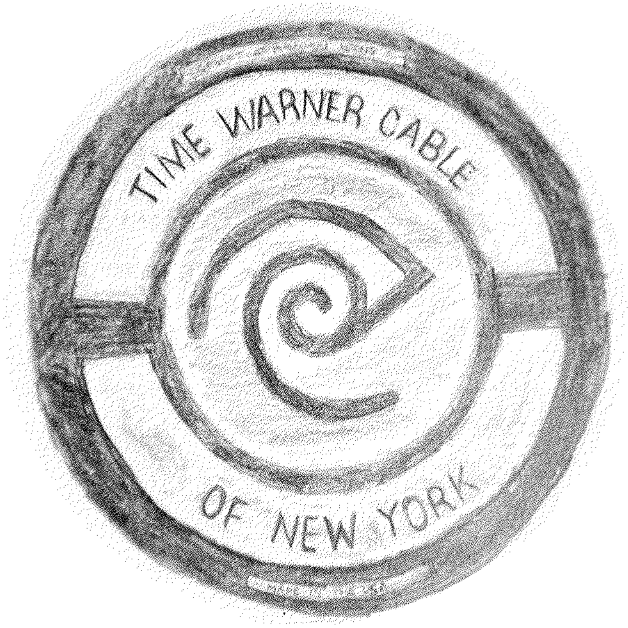


Level 3's global fiber network is massive, but the company is not a household name. This is partly because it is kind of too big to bother with residential Internet services, so it instead focuses on providing services to businesses, hospitals, and, in some cases, governments. In 2012, Level 3 received a $411 million contract from the Department of Defense's Defense Information Systems Agency (DISA) to provide fiber cable and maintenance support to DoD networks. This is not a particularly remarkable thing for a network operator to do (lots of companies provide similar services to the DoD). However, it might explain why Level 3's Chelsea colocation facility is in the same building as the New York offices of the FBI's Joint Terrorism Task Force (JTTF). Or those things could be completely unrelated; as we'll see

in later sections of this guide, New York City real estate is home to many weird overlaps of law enforcement and Internet infrastructure. This makes some sense, as both require a lot of space and security and are quite good at quietly insinuating themselves into the fabric of cities.

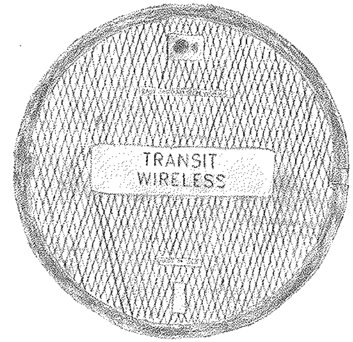
Level 3's franchise agreement with the city dates back to 1999. In 2010, an audit from the city's comptroller office determined that Level 3 had underreported its revenue to the city for a number of years. The report called on the company to pay back $543,000 in fees and interest. In 2012, Level 3 board member Rahul Merchant was named commissioner of DoITT and the city's first citywide chief information and innovation officer. At this time, it is unclear how or if the Level 3 fees issue was resolved, although Merchant is no longer on the Level 3 board and left DoITT in 2014.

TIME WARNER CABLE



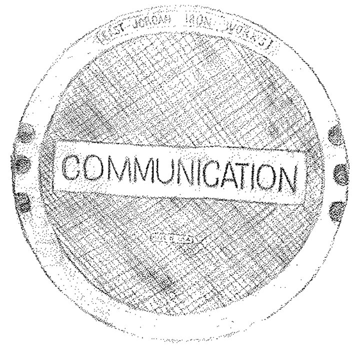
Time Warner as the Internet/television/phone services company we know came into existence in 1992 following the merger of Time Inc. and Warner Communications. They launched Time Warner Cable, one of the first high-speed cable Internet services, in 1996 before it separated from its parent company in 2009. Time Warner Cable's franchise agreement with the city of New York dates back to 1997, so presumably these manhole covers appeared sometime between 1997 and the present. Apparently that logo is supposed to be an eye merging with an ear, which is way more frightening than the hypnotic eye of Sauron that the casual observer might initially assume it represents.

TRANSIT WIRELESS



Transit Wireless was able to start placing their own manhole covers in Brooklyn in 2016 (for more, see Subway Wireless Networks).

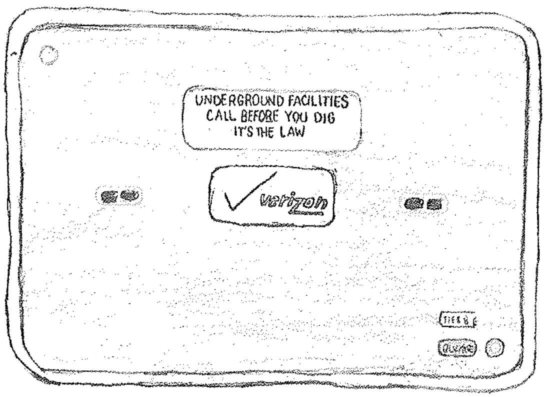
MYSTERY MANHOLES



There is a degree of hubris to the custom manhole, a hubris that assumes a business model (not to mention a corporate logo) is as enduring as a slab of steel. Though less common in New York, in many American cities telecom manhole covers are portals into their network history—the logos of now-defunct companies like Qwest and Global Crossing still live on Chicago and Minneapolis streets. These manholes don't really persist out of nostalgia but rather laziness. The cost of replacing manhole covers featuring nonexistent companies with the manhole covers of the companies that have replaced them is a lot higher than whatever gains in brand recognition the replacements might win a company.

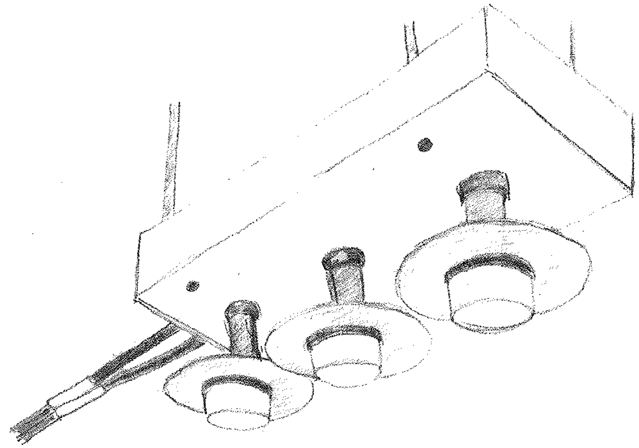
While the inevitability of corporate mortality (or rebranding following a merger) doesn't seem to deter some companies from investing in their own manholes, for those who are less inclined to make the investment, there are generic manhole covers that merely identify the use for the cables below for some kind of "communication."

HANDHOLES



Handholes are structures set belowground that protect telecommunications cables and provide convenient access for splicing or pulling cable. The primary distinction between handholes and other manhole covers is that the former aren't as deep and don't tend to be as crowded as the ducts below manholes.

SUBWAY WIRELESS NETWORKS



In 2005, the MTA issued a Request for Proposal (RFP) seeking a contractor to build out wireless services for Wi-Fi and mobile connectivity at subway stops. The company Transit Wireless formed in response to that RFP and, after receiving the contract, it formally began construction in 2007. As of 2015, the company is approximately halfway through its seven-phase building process and expected to finish connecting the entire subway system by 2017.

Transit Wireless's network is essentially a distributed antenna system (see Distributed Antenna Systems in Above Ground). The company has five "base station hotels" where mobile carriers and Wi-Fi providers connect their networking equipment to Transit Wireless's network. Each base station is located in an area strategically selected to be no more than twenty kilometers away from any of its connecting stations.

Signals from the base station travel via fiber optic cable to the connecting stations and are converted into radio signal via wireless antennae known as radio frequency (RF) nodes. At the same time, the nodes convert wireless signals from cell phones in the stations into optical signals, which get sent back to the base station via fiber. Each wireless node device has three nodes, each dedicated to a separate service: cellular service from mobile carriers, Wi-Fi services from private companies (e.g., Boingo Hotspot or Google), and public safety communications (e.g., 911 and MTA emergency services), a required feature of Transit Wireless's Metropolitan Transportation Authority contract.

Of Fiber and Finance: An Aside on High-Frequency Trading

The Financial District is a great place to look for spray-paint markings—there's often a lot of construction in the area and, as excavation markings reveal, a whole lot of cables. Finance has shaped New York in many ways, including its communication networks, and it shows on the street.

High-frequency trading (HFT) was a technological shift in the financial world that emerged around 2005. Broadly speaking, HFT uses complex algorithms to automate huge quantities of trades over very short periods of time, taking advantage of small differences in price across markets or between bidding and selling prices. These differences might be fractions of pennies, but by performing millions of trades at fractions of seconds, HFT firms are able to

make huge profits. In 2009, HFT accounted for 60 percent of all trades in U.S. stocks.

The pursuit of a microsecond advantage led to a lot of demand on Wall Street for low-latency networks, a term used to describe length of delay in data transmissions. Lower latency means less delay and faster trades. After apparently reaching the limits of mathematics for increasing speed, traders turned to physical proximity for lower latency. Data centers that housed stock exchanges offered expensive colocation services that placed a trading firm's servers closer to the exchange servers to improve latency (since the cable connecting the servers was shorter, data traveled a shorter distance and got to the server faster). New companies emerged, promoting ultra-low-latency networks by leasing private fiber lines. One company, Spread Networks, built an entirely new fiber optic network from Chicago to New York to be able to achieve—and charge hundreds of thousands of dollars for—a three-millisecond advantage.

Just like its trades, HFT has changed rapidly over a short period and probably will change even more by the time this book is published. There have been retreats into private "dark pools" run by banks, and the efficiency of algorithms has reduced the very volatility those algorithms gamed. At the same time, low-latency fiber is being rejected in favor of wireless microwave networks (as data traveling even slightly less than the speed of light in a fiber optic cable isn't quite fast enough).

As the black boxes of finance become increasingly opaque, it's weirdly reassuring to be able to identify their limited physical traces in downtown Manhattan—although, it turns out, most of the major exchanges and banks now choose to keep their servers in nearby New Jersey.