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The technology that gave the world cryptocurrency is poised to deliver a new capability powered by GEOINT: cryptolocation.

BY MATT ALDERTON

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THE WORLD IS BUZZING ABOUT BLOCKCHAIN. To understand what it actually is, one must start with bitcoin, for which the bubble burst in 2018. Or so suggest the numbers. When the first-ever bitcoin exchange stood up in 2010, online traders valued the controversial coin at just $0.003—less than a penny. Seven years later, in December 2017, bitcoin escalated when its value reached an all-time high of nearly $20,000 per coin. Then, suddenly, what went up came crashing down. By January 2018, bitcoin had lost 30 percent of its value, and a year later it was down 80 percent. Millions were made, then lost. Observers wondered: Was cryptocurrency a tidal wave in the global economy, or just a drop in some huckster's bucket?

Although bitcoin's future is ambiguous, so is its past. Established in 2008, its creator is an anonymous party known only by the pseudonym Satoshi Nakamoto, who in August 2008 registered the bitcoin.org domain and two months later published a whitepaper that laid the foundation of the bitcoin universe. Nakamoto outlined and subsequently launched a digital currency consisting of virtual tokens that are "mined" from bitcoin's software by computers that solve complicated mathematical problems in exchange for rewards. Because users can anonymously trade and transact extracted tokens without intermediaries like governments and banks, the system is entirely decentralized.

If this sounds complicated, that's because it is. But complexity isn't what drove cryptocurrencies into a bear market. Instead, it was higher stakes and scrutiny; the more valuable bitcoin became, the more attention it attracted from hackers and regulators, which undermined user confidence.

Whether bitcoin lives or dies, the blockchain concept on which it relies has a promising future. Because with the same basic logic, architecture, and algorithms, one can securely transact information just as easily as one can transact currency—including location information, whose potential coupling with blockchains is inspiring a wave of innovation that promises new benefits for the geospatial intelligence (GEOINT) community.

UNDERSTANDING BLOCKCHAIN THROUGH BITCOIN

Bitcoin relies on an **international community** of devotees who have agreed to run special software on their computers, forming a global network of machines that is bitcoin's infrastructure. When users transact with bitcoin, they do so using two unique alphanumeric codes. One, called a **private key**, is secret. The other, a **public key**, is exposed. The former is akin to a password and the latter to an account number. To send a payment, users initiate a transaction from a **digital wallet** and "sign" it with their private key. Along with basic transaction data—how much bitcoin one is sending, for example, and to whom—the private key is encrypted using a dedicated algorithm whose alphanumeric output is known as a signature.

Signatures subsequently are broadcast to the aforementioned network of computers, some of which are tasked with validating transactions. By matching signatures to public keys, the computers can confirm—without ever knowing the sender's identity—that the bitcoin being transacted belongs to the sender and is actually available to send.

For expediency, transactions are verified and recorded in chunks known as blocks, each of which has its own alphanumeric code called a **"hash"** that represents the transactions inside it while also referencing the block before it. In that way, each block connects to the next, forming a "blockchain." The **blockchain** is considered immutable because a single change to a single block will generate a new hash that no longer aligns with the rest of the chain behind it, causing a cryptographic domino effect that "breaks" the chain.

Furthermore, each computer in the bitcoin network stores its own copy of the blockchain, the result of which is **a distributed architecture that builds trust by consensus**. Which is to say: One computer can't change the blockchain unless a majority of other computers on the network agree with it. The pairing of immutability with consensus **makes fraud and falsification improbable**, if not impossible.

SCHOOL OF BLOCK

To understand how the GEOINT Community might leverage blockchain, one must first understand what it is.

"Blockchain is not bitcoin," said Ali Husain, director of SparkCognition Labs, the research and development group within SparkCognition, an Austin-based AI company that uses blockchain. "There's a widespread misunderstanding that they are one and the same. Blockchain is the technology, and bitcoin is one of its many applications."

In that way, a blockchain is like an operating system. Similar to iOS or Android on a smartphone, blockchain is invisible to users but delivers features and benefits through an infinite number of potential software applications.

Arie Trouw likens blockchain to a QuickBooks register. "It's a series of entries in a ledger," explained Trouw, founder and CEO of XYO, a San Diego-based company on a mission to decentralize location data. "What makes it so special is that each entry is linked to the previous entry with cryptography in such a way that it can't be changed."

Blockchains can be public—anyone, anywhere can join the network—or private: only permissioned parties may join the network. In both cases, the ledger is copied and stored on each machine in the network for the purpose of consensus.

"Blockchains by nature are distributed," said Mark Barber, former head of product enablement at BTL, a Vancouver-based company with its own blockchain platform. "That means instead of doing any storage or compute of information in a single place, it's done in a number of places concurrently. So if one machine that operates the blockchain fails, the blockchain will continue to operate because it has built-in redundancy."

The benefits are numerous—starting with cybersecurity. "There's not one centralized database a bad actor can go into and compromise," Husain explained. "In fact, if something like this happens in a blockchain-based system, it's very apparent that something has been tampered with."

A related benefit is transparency, according to Barber, who once heard someone describe blockchain as taking systems from "what you see is what you get" to "what you see is what I see." "Instead of you seeing your data and me seeing my data, what we see is our data because we're looking at the same computing platform," he said.

Transparency enables truth, and from truth comes trust. "In my mind, blockchain fundamentally is a novel way for computers—and therefore people—to agree," said Robert Keenan, product lead at ConsenSys Solutions, the consulting practice of New York-based blockchain company ConsenSys. "Now we can have a global system where computers trust each other, and where people can trust the data that comes from those computers. That unlocks opportunities for individual agency where you no longer need to rely on third parties for certain tasks."

CATALYZING COLLABORATION

In the GEOINT Community, blockchain can help solve real challenges. For instance, that of open governance. "Our clients' biggest need is to enable a kind of data sharing that doesn't exist today," said Matthew Nelson, a blockchain consultant at IBM. "You have a business network of different participants … but you don't necessarily have a singular or consolidated way to enable a business process across those members without using a technology like blockchain."

Private blockchains, in particular, give entities operating on disparate systems—the Intelligence Community, for example—a shared mechanism through which to achieve a common operating picture; when they contribute to the blockchain, their contribution is broadcast across the entire network and recorded permanently on a shared ledger.

"If you have multiple participants on the blockchain network, and one of those participants needs to be removed from the process, you still have a record of what that participant has been doing and provenance of all their actions," Nelson said.

Although the agency told *trajectory* it's not yet prepared to discuss blockchain, the National Geospatial-Intelligence Agency (NGA) is an ideal candidate for blockchain-based data sharing, according to Nelson. "NGA has been struggling with the provenance of data … because its business network is so broad," he explained. "If you use a blockchain to consolidate those network members around a single source of truth, you'll see that brokered data is easier to manage

because you can track it from the time you receive it all the way through to the time the end user gets it, which allows you to maintain its integrity."

The nonprofit Radiant Earth Foundation, which aggregates open Earth imagery for use by global aid organizations, recently executed a proof-of-concept in precisely this domain. After a disaster, NGOs often need commercial satellite imagery to inform response and recovery efforts. Although it's useful, such imagery is expensive. What many don't realize, however, is that the licenses NGOs obtain from commercial imagery providers often allow them to share data with others in their mission space. By moving licensing governance to a blockchain, Radiant Earth Foundation theorized, it could increase access to commercial imagery and improve humanitarian outcomes.

"For instance, the Bill & Melinda Gates Foundation has over 10 terabytes of commercially licensed data, most of it from DigitalGlobe and most of it of the continent of Africa," said Radiant Earth Foundation founder and CEO Anne Hale Miglarese. "When they negotiated the license, they negotiated that it could be shared with other nonprofit people and organizations working in the global development community. But because that data sits on a drive in their GIS expert's office, nobody knows they have it. The main driver of our project was to get all that imagery from the philanthropic organizations that have it and make it more broadly available."

Imagine, for example, relief workers engaged in a humanitarian project in Ghana. When they log onto the Radiant Earth Foundation's platform, they see DigitalGlobe imagery from the Gates Foundation's repository, which they can access. Behind the scenes, the blockchain confirms identities and creates records.

"It assures commercial providers that we are taking care and respect their license, but it also shows them that their data is being used," continued Miglarese, who concluded the pilot project in September. "Going from proof-of-concept to full-scale implementation this early in the landscape feels too risky to me, but I do believe there is real possibility to increase the spread of data and people sharing it."

Echoed Keenan of ConsenSys, Radiant's partner on the project, "It's a nascent technology, but what we're building is a longer-term vision for improving interoperability across the entire ecosystem."

TOKENS OF APPRECIATION

Radiant Earth Foundation isn't the only organization that has noticed the potential of underutilized GEOINT data. So has Soar, an Australian startup that wants to build what it calls "the world's first fully decentralized global super-map."

Built on blockchain technology, Soar's map resembles Google Maps in spirit. Instead of static, low-resolution satellite imagery, however, it features dynamic space- and airborne-based imagery. Continuously updated, the imagery spans resolutions and spectrums, encompassing natural and false color, multispectral, thermal, and even LiDAR. The map—the beta version of which launched in October—is searchable at the pixel level; is "multi-scale," meaning users can seamlessly zoom from a faraway satellite view to a close-up drone view; and contains image histories so users can witness pixel-level changes over time.

"Our goal is to build a massive repository of every single type of remotely sensed data," explained Soar founder and CEO Amir Farhand.

To build the dynamic global map it envisions, Soar needs imagery, 80 percent of which it says is underutilized. In particular, it needs drone imagery, the vast majority of which is captured by individual operators who take images they never share.

"You've got data providers all over the world, including everyday people with drones. What happens to their data?" Farhand asked. "In most cases, it's siloed and never sees the light of day. What we encourage people to do is put that data onto Soar."

And so emerges another promising outgrowth of the "geoblockchain:" incentivized mapping.

Although the imagery itself is stored in the cloud, Soar stores drone imagery metadata—including location, altitude, time, and equipment used—on a public blockchain, where a proprietary algorithm validates the authenticity of the footage to ensure its integrity for users who might include anyone from cable news producers to intelligence analysts. Meanwhile, it also uses the blockchain to support its own micro-economy, the centerpiece of which is a bitcoin-like token called the SkyMap (SKYM). Although it's not a currency, SKYM functions like one within the Soar platform: When their imagery is validated and uploaded to Soar, drone operators are automatically compensated with tokens they can use to purchase or sponsor other Soar content. Those who wish to sponsor content can do so through Soar's SkyBounty system, wherein users can incentivize fellow operators to gather and share imagery of particular locations.

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>
> —ALI HUSAIN, SPARKCOGNITION LABS

"If we were going to incentivize [drone operators] via [government-backed] currency, it would cost us millions of dollars we don't have," explained Farhand, who said SKYM gives Soar a means to scale quickly, affordably, and securely.

The potential of incentives is further evident in another blockchain-based platform, New York-based StreetCred, whose goal is to create a global dataset of "points of interest" (POI) data for use by small businesses and software developers. Such data—the hours of a store, whether a restaurant is wheelchair-accessible, the location of a popular swimming hole—often is inaccessible and incomplete, according to StreetCred CEO Randy Meech. At one end of the POI ecosystem, he said, are solutions like Google Maps, whose data generally is available only to developers who can afford a hefty fee for the Google Places API. At the other end are organizations like OpenStreetMap, whose crowdsourced datasets are open source, but often unfinished. While a fitness company might want to know the locations of all parks and gyms in a given city, for example, there's no guarantee the OpenStreetMap community has mapped them.

To fill the gap between Google Maps and OpenStreetMap, StreetCred is building a blockchain-based POI marketplace through which developers

who need place data in specific geographies or verticals can incentivize citizen mappers to generate it in exchange for digital tokens that can be used within the platform or converted into fiat currency.

Because blockchains are consensus-driven, data can only be added to a map when other users verify it; users who post accurate data receive tokens as a reward and users who post inaccurate data lose them as a penalty. And because blockchains are decentralized, the StreetCred community and the data it generates can live on, even if their creators do not.

"It can't be shut down. Bitcoin is a good example. Because there's no central authority to bitcoin, it's permanent infrastructure. As long as there are people who want to [participate in the system], it exists," Meech said.

Encompassing everything from doctor's offices in Manhattan to restaurants in Mumbai, the resulting data could be a catalyst for future GEOINT transformation. "We've seen it with open data before: When you make this stuff available, really interesting innovations come about that you couldn't have even imagined before," Meech said. "You can see a lot of monetizable use cases for [POI data] today, but we've likely seen just the tip of the iceberg."

PROOF OF LOCATION

Two other companies utilizing crypto-incentives are XYO and FOAM, each of which is focused on proof of location.

"We started thinking about all the use cases people are excited about when it comes to blockchain, and we realized: All of them involved the real world, but so far we've really only seen blockchain applications that work on the internet," said FOAM co-founder and CEO Ryan King, who recognized that in order to interact with the real world, blockchains need mechanisms to record and verify location. "So, we started building tools … to bring geodata to the blockchain."

FOAM's system relies on radio beacons that network participants operate in their homes or businesses in exchange for FOAM tokens. When a beacon is installed, it locates three other beacons in its vicinity and forms a "zone" with them. Beacons have atomic clocks inside that synchronize with each other when a zone is formed, at which point customers can enter the zone and request a "presence claim," which is essentially a receipt of their location. The zone's beacons use triangulated timing signals to calculate the customer's position, which is subsequently verified and recorded on a public blockchain. Finally, the customer receives a verified presence claim that could serve them in a variety of diverse applications.

A rideshare customer, for instance, might use proof of location to ensure the car she ordered is the one in front of her and not the one down the street. A plumber, meanwhile, might use it to prove to his employer that he actually showed up to a customer's house. Disaster victims could use it to prove they live in a disaster zone in exchange for relief. And reporters could use it to combat fake news by proving they actually witnessed an event they're covering.

Although the system is similar to GPS, it's different by design. "With GPS you don't have proof of location because it's a one-directional system. You can receive your location but you can't talk back to the system, so there is no history of your location that allows you to prove you were in a certain place at a certain time," explains King, who said other flaws with GPS include: it's easily spoofed; it doesn't work well indoors, underground, or in urban environments; and it's a single point of failure, which leaves it vulnerable to attack. "Because there's no way to generate a receipt with GPS, you can easily change your GPS data and share it with someone else. That's not going to cut it in a decentralized economy."

XYO takes a different approach. Its solution, the XYO Network, leverages small, low-cost electronic devices called "Sentinels." Sentinels can be carried on one's person or attached to virtually any object one wants to track. As they move through the world, they communicate with each other while cryptographically collecting and storing GPS coordinates. One Sentinel "shakes hands" with another and makes a location-based record of the interaction on a digital ledger that is later uploaded to a public blockchain. There, anonymized data can be parsed and cross-referenced to answer location-based queries.

The handshake is how the XYO Network achieves the consensus for which blockchains are known. Here's an example XYO often uses: Imagine someone shipping a birthday gift to a loved one. Because they want to ensure the package arrives safely, they ship it with a Sentinel in the box. When the package arrives, the Sentinel inside the box communicates with a Sentinel located in or near the recipient's home. The sender can then query the XYO Network to ask if the package arrived and determine that it did. While present-day package tracking tells you what city your package is in on what day, the XYO Network offers street-level detail in real time.

Again, tokens fuel the process: When someone queries the network, they must pay XYO tokens to get an answer. In return, anyone whose Sentinel helps produce the answer receives some of those tokens, thereby incentivizing people and businesses to participate in the network.

"Our goal is to instrument the world with these devices and build a massive network of data that does not require a central owner to be trusted," said Trouw, who hopes Sentinels eventually will be embedded in everything from smartphones to shipping labels.

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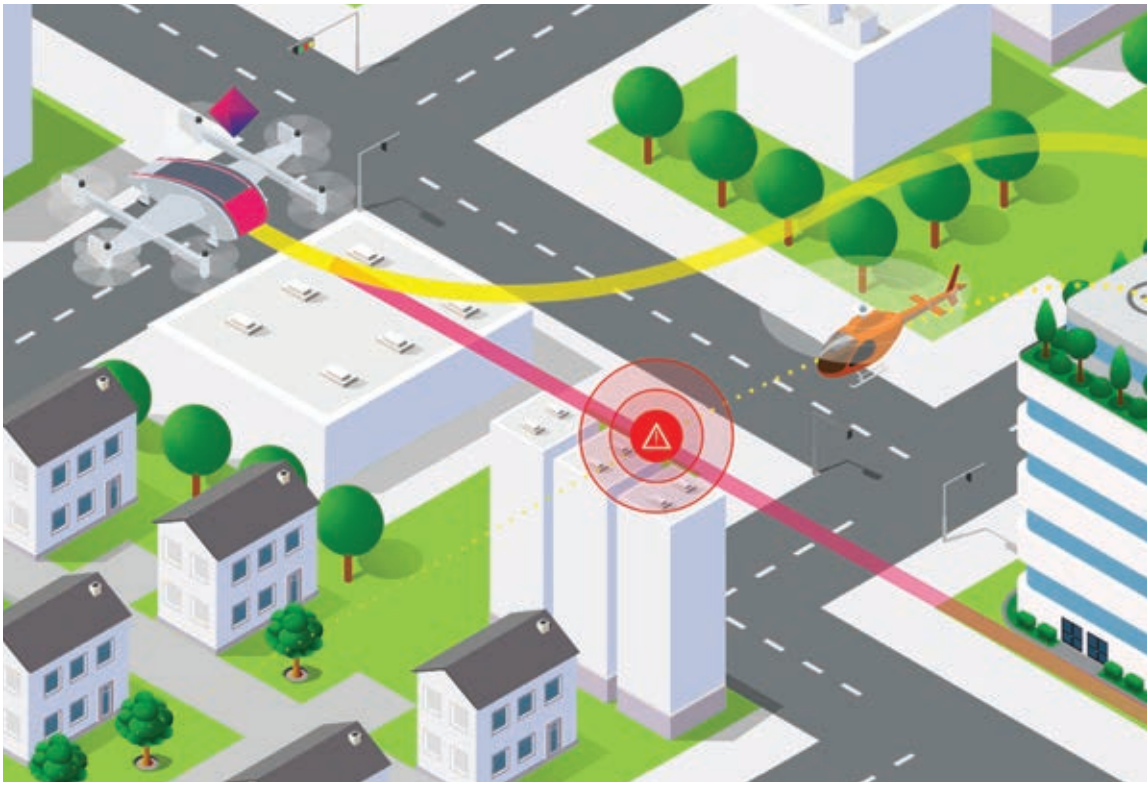
> —MATTHEW NELSON, IBM

BLOCKCHAIN OR BUST

Startups aren't the only ones who see proof-of-location potential. Traditional GEOINT enterprises also are staking claims, suggesting blockchain might soon reach its tipping point. In November, for example, Boeing announced a joint venture with SparkCognition. Called SkyGrid, it's creating an aerial operating system that will apply AI and blockchain to air traffic control for drones.

"Blockchain is an integral part of SkyGrid because it allows us to maintain high standards of safety and auditability," explained SparkCognition's Husain, who also serves as SkyGrid's chief software architect. Every drone in the system, he said, will have a unique ID that will be used to identify it

IMAGE COURTESY OF SKYGRID



SkyGrid plans to develop a platform that will facilitate the smooth integration of autonomous cargo craft and passenger air vehicles in the global airspace.

in the blockchain, where everything from its flight path to its maintenance history will be recorded. "This data, once written, cannot be tampered with. And in the case of a regulatory authority such as the [Federal Aviation Administration] needing access to flight records, they can be sure of the data integrity."

IBM is pursuing similar ends of safety and auditability. In 2018, it launched the IBM Food Trust, a blockchain developed in partnership with Walmart and other grocers to create transparency across the global food supply chain.

"They're tracking the lifecycle of food items from farm to distributor to store to end consumer," IBM's Nelson said. "And the reason they're doing that is, when there's a foodborne illness outbreak like there was with romaine lettuce in 2018, they don't want to have to throw out all the lettuce. They want to target the individual farm or distributor [where the outbreak originated] and pull only those items."

Walmart's former VP of food safety, who helped develop and test the blockchain, now works for the U.S. Food & Drug Administration, which has expressed interest in a food-safety blockchain of its own. In February, it launched a pilot project to test a blockchain for tracing pharmaceutical supply chains.

Other federal agencies that have dipped their toes in blockchain waters include:

- The U.S. State Department, which launched a pilot project in 2018 to establish a blockchain registry for international workers and their contracts, the goal of which was to prevent forced labor;
- The Centers for Disease Control and Prevention, which in 2018 tested a blockchain-based system for tracking public health issues like the opioid crisis;
- And the Department of Homeland Security, which is exploring how blockchains could help it prevent counterfeiting and forgery, track cross-border oil imports, and trace the origin of other raw material imports.

THE WEAKEST LINK

Blockchain presents major opportunities, but also major challenges. And despite its complexity, the challenges have more to do with people than technology.

"Blockchain theoretically is a great concept, and what we can do with it has a lot of benefits to a lot of organizations. What has to happen for us to realize those benefits, though, is a large-scale adoption of it across multiple agencies," said Kevin Bolger, practice lead for AI and machine learning at Esri, which is helping companies like XYO spatially enable blockchains. "For example, blockchain could benefit the question of sales tax within the U.S. because when we do online sales we have to track where a sale was done and what municipality or state gets credit for that sales tax. We can use blockchain to track that, but in order to do that we have to have mass adoption of blockchain not only across state and local governments, but also among retailers."

Echoed Nelson, "The problem lies not with building out the technology, but with governance of the network, which requires getting different groups into one room to sit down and decide how they want to do data sharing."

Indeed, the move from centralized to decentralized business processes is as cultural as it is technological.

"You have big issues and questions as far as where the world of data is going," explained Trouw, who said entities must answer a host of legal and regulatory questions before blockchain goes mainstream. "What defines data ownership? How do I use my own data? Can I control it? Those more esoteric questions are very important, because if data is being shared in a public view, it can be used for good and for evil."

It's a reputational problem as much as anything else. "[Solutions like StreetCred] need people to believe in the value of cryptocurrency and have a positive perception of it," Meech said. "Because of the hype, and because there have been some scams, the trustworthiness of the industry in general is a challenge."

Speaking of hype: You have to cut through it in order to see blockchain's true potential. "If you think about all the tech products you use right now, how many of them could benefit from being on the blockchain? I'd argue not many," concluded Farhand, who added blockchain's limitations—it's notoriously slow at data processing, for example, and remains too technical for everyday consumers to grasp—might preclude it from ubiquitous use. "But in a siloed fashion—defense applications, mapping applications, insurance, logistics, health care—all of a sudden it becomes very, very palatable and genuinely game-changing."