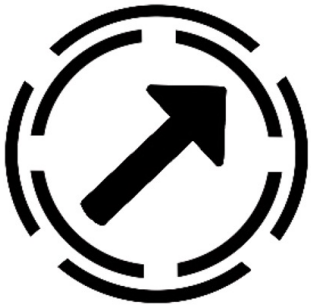


Escape Velocity

DeWi: Beyond Networks

"The market potential for cellular communications appears very limited… Significant incremental market growth will not result from changes in either price or other product service attributes... Even high potential segments of the population demonstrate very limited interest in cellular communications, at any price." — McKinsey, 1985

Call it proof of physical work, token-incentivized physical infrastructure networks, phygital NFTs, or simply web3 infrastructure: there's an undeniable emergence of crypto-networks that enable users and developers to interact with the physical world in trust-minimized ways. We count 35+ active projects in the space, connecting 1M+ on-chain daily-active devices, with a fully-diluted liquid market cap of $10B+. We categorize them as follows:

- **Decentralized radio networks** focusing on cellular (Helium 5G, Pollen Mobile, XNET); WiFi (Althea, Wayru, WiFi-Coin, WiCrypt, WiFiDabba); LoRa (Helium LoRa, Foam, Mesh+); Bluetooth (Nodle); or satellite (Geod)
- **Decentralized sensor networks** focusing on environmental data (WeatherXM, Planetwatch); vehicles (Dimo, Soarchain); maps (Hivemapper, RealityCoin); health (Stepn, Sweatcoin, Healthblocks); or general purpose IoT platforms (IoTeX, IOTA)
- **Decentralized server networks** focusing on storage (Filecoin, Arweave, Sia); content delivery (Meson, NKN); or privacy/security (Sentinel, Boring)
- **Decentralized energy networks** that connect energy production and storage devices (Anode, PowerLedger, Blue Morpha)

		Overview		Total Network ($M)		Per Active Node ($K)				
		Daily Active Nodes	Fully-Diluted BV Multiple	FDV	Hardware Costs	FDV	Est. Hardware Costs	Layer-1	Region	Block Explorer
Radios	Helium 5G	4,000	47x	$375	$8	$94	$2.0	Native / Solana	US	https://explorer.helium.com/mobile
	Pollen	2,200	64x	$140	$2	$64	$1.0	Solana	US	https://explorer.pollenmobile.io/stats
	Althea	–	–	–	–	–	–	Cosmos	US / Latam	–
	Wayru	–	–	–	–	–	–	Algorand	US / Latam	–
	WiFiCoin	–	–	–	–	–	–	Ethereum	UAE	–
	WiCrypt	500	43x	$16	$0	$32	$0.8	Polygon	Nigeria	https://scan.wicrypt.com/
	WiFi Dabba	–	–	–	–	–	–	–	India	https://wifidabba.com/map
	Helium LoRa	625,000	4x	$1,250	$313	$2	$0.5	Native / Solana	Global	https://explorer.helium.com/iot
	Mesh+	–	–	–	–	–	–	IOTA	–	–
	Nodle	500,000	–	$135	–	$0.3	–	Polkadot	Global	https://nodle.subscan.io/
	XNET	–	–	–	–	–	–	–	US	–
	Giant	–	–	–	–	–	–	Polkadot	Global	–
	Foam	4	233x	$28	$0	$7,000	$30	–	–	–
Sensors	WeatherXM	700	–	–	$0	–	$0.4	Polygon	US / Europe	https://explorer.weatherxm.com/
	Planetwatch	73,000	0.5x	$28	$55	$0.4	$0.8	Algorand	Global	https://explorer.planetwatch.io/#/
	Dimo	2,800	–	–	$1	–	$0.2	–	US / Europe	https://explorer.dimo.zone/
	Soarchain	–	–	–	–	–	–	–	–	–
	Hivemapper	450	–	–	–	–	–	Solana	US	https://hivemapper.com/explorer
	Realitycoin	–	–	–	–	–	–	–	–	–
	Stepn	7,000	–	$4,400	–	$629	–	Solana	Global	https://dune.com/queries/621702
	Sweatcoin	–	–	–	–	–	–	–	Global	–
	IoTeX	15,000	600x	$315	$1	$21	$0.04	Native	Global	https://iotex.io/
	IOTA	–	–	$825	–	–	–	Assembly (Native)	–	https://explorer.iota.org/mainnet
	Healthblocks	–	–	–	–	–	–	–	–	–
Servers	Filecoin	4,000	–	$1,750	–	$438	–	Native	Global	https://storage.filecoin.io/
	Arweave	66	–	$745	–	$11,288	–	Native	Global	https://viewblock.io/arweave
	Sia	725	–	$215	–	$297	–	Native	Global	https://siastats.info/hosts
	Meson	14,000	–	–	–	–	–	Ethereum	Global	https://explorer.meson.network:1984/
	NKN	75	–	$105	–	$1,400	–	Native	US	https://explorer.nkn.org/
	Sentinel	5,000	–	$15	–	$3	–	Cosmos	Global	https://stats.sentinel.co/stats
	Boring	50	–	$2	–	$32	–	Solana	Global	https://boringprotocol.io/
Energy	Anode	–	–	–	–	–	–	–	–	–
	PowerLedger	–	–	$220	–	–	–	Solana	–	–
	Blue Morpha	–	–	–	–	–	–	–	–	–

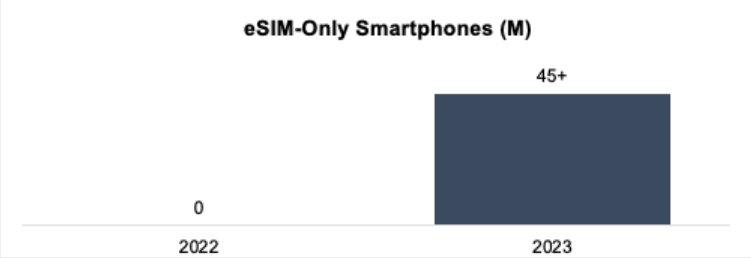
Source: Escape Velocity research

Today's letter focuses on the first category, a phenomenon we call *DeWi.* DeWi is revolution in how communications networks are built, operated, and owned—and it's happening as we speak. Since our last letter focused on network design, today we'll focus on second-order impacts of DeWi networks and the resulting opportunities for entrepreneurs.

DeWi's Time Has Finally Come

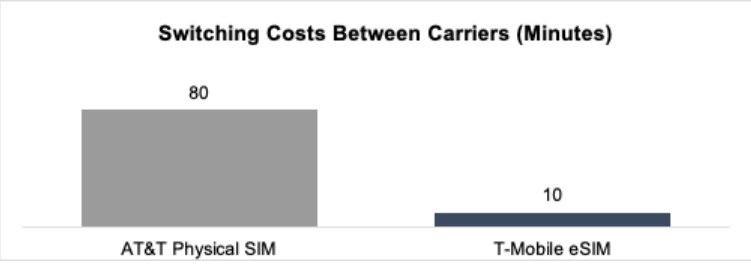
The real test of a thesis isn't "how big?", but "why now?" DeWi skeptics are quick to point out that spectrum sharing, ISP-in-a-box, mesh networking, and connectivity-sharing are all ideas that have been tried over the past decade with few successes. Despite that being true, when we put ourselves in the shoes of customers and entrepreneurs *today*, it's obvious that the telco industry is undergoing a 0-to-1 transformation with hundreds of billions of dollars at stake. Here are a few facts to consider:

1. **eSIMs have been around since 2018, but are now going mainstream.** Earlier this month, Apple announced the iPhone 14 will have three times as many eSIMs as the prior generation (6 vs 2 eSIM slots), and - more importantly - will have **zero** slots for physical SIM cards. Given Apple's production targets (95M+ iPhone 14s) and geographic split (40-50% US), we can assume **45M+ consumers will have eSIM-only iPhones next year.**



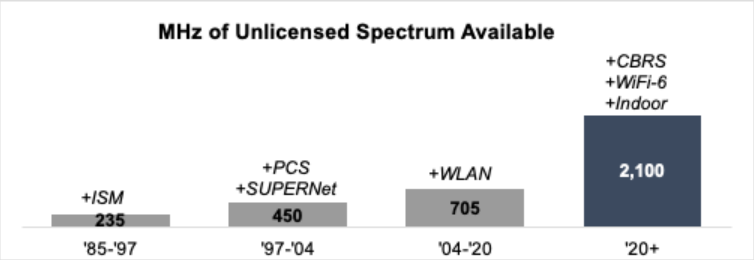
Source: MacRumors, BusinessOfApps

2. **eSIMs drive carrier switching costs down to near-zero.** To test this theory, I (an 11-year Verizon customer) finally switched carriers. To join AT&T, I drove 15-minutes each way to the closest AT&T store and spent almost an hour signing up, guided by my very-friendly-but-clearly-paid-by-the-hour AT&T rep. To join T-Mobile, I downloaded an app and completed onboarding in less than 10 minutes, most of which was waiting for my eSIM to activate (if don't believe me - watch this 30-second video or try the app yourself). eSIM product experiences are still nascent but will continue to improve, especially with Apple supporting native eSIM transfers via Bluetooth in iOS 16. Less than a week after Apple's announcement, Verizon guided Wall Street towards its second consecutive quarter of negative net post-paid subscriber growth, sending $VZ stock to decade-lows. This more than just a bad quarter, it marks the beginning a fundamental shift in how consumers treat telcos: less like utilities, and more like services. **The 1-2% monthly churn historically enjoyed by carriers is coming to an abrupt end in 2023.**



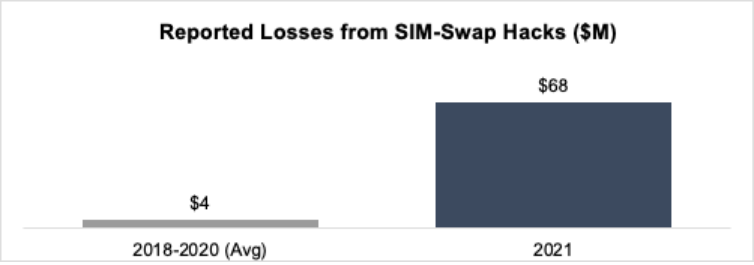
Source: Escape Velocity research

3. **There is more unlicensed spectrum available to entrepreneurs than ever before.** The vast majority of WiFi and Bluetooth technologies we use every day were built on 235 MHz of unlicensed spectrum that were set aside in 1985. Despite this sparking innovations that drove >$40B/yr of economic benefits, the FCC never doubled-down on unlicensed spectrum—until now. **The amount of unlicensed spectrum in the US tripled over the 35 years leading up to 2020; over the following 12 months, it tripled again.**



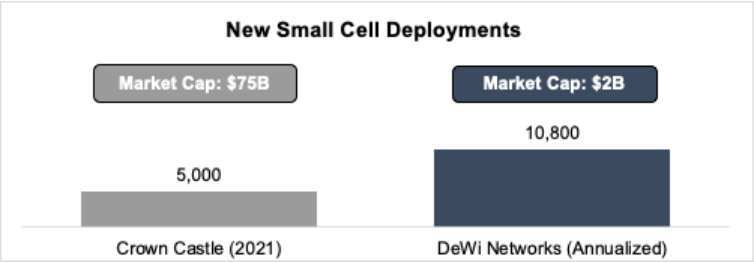
Source: Federal Communications Commission; excludes bands >60 GHz

4. **Vulnerable communications networks are being exploited by both state and non-state attackers.** In 2021, hackers discovered one of the weakest links in the entire consumer internet supply chain: telcos' customer support departments. In a SIM-swap attack, an attacker calls a telco's customer support line and convinces the agent to transfer the victim's SIM onto the attacker's phone. Once this is done, a hacker can intercept every message and call, including SMS-based two-factor authentication for most email, social media, and bank accounts. As a result, SIM swaps can be devastating: the average reported loss is >$40K. **Losses from SIM-swap hacks grew >17x in 2021, driving higher churn for incumbents and providing an opportunity for challengers to differentiate on security/privacy.**



Source: Federal Bureau of Investigation

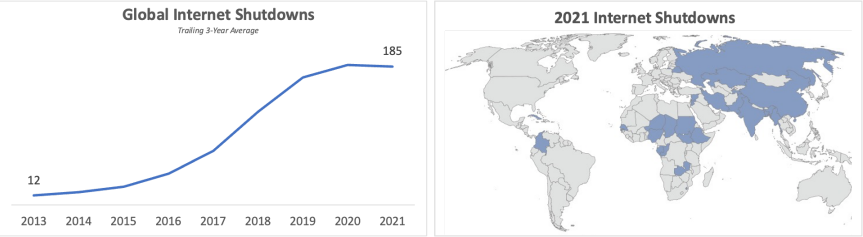
5. **In some aspects, such as live data transfer, DeWi networks are still nascent; in others, DeWi is already outpacing the incumbents.** Helium and Pollen's small cell LTE radio networks are growing >50% MoM, with miners deploying >900 new outdoor radios in the past 30 days. In major cities like San Francisco, DeWi is already reaching density with >200 nodes actively providing coverage. In fact, on an annualized basis, **DeWi is deploying more than twice as many outdoor small cells as Crown Castle, the largest small cell operator in the US.**



Source: Crown Castle earnings call; Helium and Pollen explorers

6. Ethereum's homepage proudly states: "Ethereum's decentralized finance system never sleeps or discriminates. *With just an internet connection,* you can send, receive, borrow, earn interest, and even stream funds anywhere in the world" (emphasis added). Relatively few people in crypto are focused on the italicized part, but we think it's

incredibly important: what's the point of having a censorship-resistant blockchain if governments around the world regularly shut down citizens' internet access? **Governments are blocking internet access >10x more often than in years past.**



Source: Carnegie Endowment for International Peace, AccessNow, Netblocks

💡 ***The internet has become pervasive and as a society we use it more and more every day — yet the networks we rely on are expensive, fragile, and vulnerable to abuse by both "insiders" (governments) and "outsiders" (hackers). At the same time, the moats of telco incumbents, i.e. switching costs and spectrum licenses, are being dismantled by the exogenous shocks from eSIMs and unlicensed spectrum. For entrepreneurs and risk-oriented investors, the time to build decentralized communications networks is right now.***

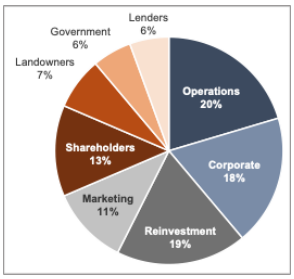
The Size of the Prize: $270B+

Note: this essay refers to US opportunity only; future essays will explore global markets. "Telcos" represent combined Q2'22 annualized financials for AT&T + Verizon + T-Mobile. "Towers" represent combined Q2'22 annualized financials for American Tower + Crown Castle + SBA.

In Q2'22, telcos generated $270B of annualized revenues, which went towards:

- **Network Operations: $55B/yr (20%).** Telcos generate 80% gross margins, which would put them in the top quartile of public SaaS companies (operating networks isn't actually that expensive — as we've argued in the past, telcos are good businesses).
- **Corporate Overhead: $50B/yr (20%).** Managing the network costs $125K per employee, which is roughly in line with US banks ($150K average annual compensation per employee for JPM/BAC/C/WFC), suggesting DeWi can have a similar cost-savings impact as DeFi.
- **Reinvestment: $50B/yr (20%).** Telcos are roughly halfway through a decade-long, $500B investment cycle into 5G. The vast majority of this capital is for densifying networks and improving capacity only in the top-50 urban markets. Rural markets are more or less ignored.
- **Customer Acquisition: $30B/yr (10%).** Despite enormous marketing budgets and low customer churn, telco revenue growth of <2% lags inflation. Marketing dollars are spent competing amongst each other, ultimately benefiting Apple/Samsung more than telcos.

	US Telcos Q2'22 Annualized Revenues ($270B)		
		$ Billion	
Network Operations (40%)	Operations	$55	<< *core network operates at 80% gross margin*
	Corporate	$50	<< *300M Americans @ $165 per capita*
Network Growth (30%)	Reinvestment	$50	<< *halfway through a $500B+ 5G upgrade cycle*
	Marketing	$30	<< *revenue growth still lags inflation (<2%)*
Stakeholder Payouts (30%)	Shareholders	$35	<< *$300B equity @ 12% earnings yield*
	Landowners	$20	<< *130K+ towers @ $150K average rent*
	Government	$15	<< *typically higher; no auctions in Q2'22*
	Lenders	$15	<< *$350B debt (3x EBITDA) @ 4% cost of debt*



The orange category - $85B/yr in stakeholder payouts - represents the cost of financing telcos' $1T balance sheet, broken down as follows:

- **Assets:** $445B of physical and other assets are dwarfed by intangible assets, including $375B of spectrum licenses, $135B of goodwill, and $45B of receivables. This deeply impacts returns on invested capital, effectively cutting asset yields from 61% ($270B revenues using $445B of assets) down to 27% ($270B using $1T of total assets).
- **Liabilities:** Lenders earn 4% on $350B of debt, shareholders earn 12% on $300B of equity, and towers are owned by third-party landlords earning 15-20%. There's also $100B of deferred taxes liability funding, on which the government earns 11%+ cash returns via income taxes (before spectrum fees).

Balance Sheet (Q2'22)					
Assets			**Liabilities**		
	$ Billion	%		$ Billion	%
Spectrum Licenses	$375	38%	Lenders (Debt)	$350	35%
Intangible Assets	$180	18%	Shareholders (Equity)	$300	30%
Physical Assets	$350	35%	Partners (Payables & Leases)	$250	25%
Other	$95	10%	Government (Deferred Taxes)	$100	10%
Total Assets	**$1,000**	**100%**	**Total Liabilities & Equity**	**$1,000**	**100%**

	Return on Capital
Lenders	4%
Government	11%+
Shareholders	12%
Landlords	15-20%

This provides a rough sketch of DeWi's market opportunity. From telco income statements:

- A **$55B/yr** opportunity to **improve core network operations.**
- A **$50B/yr** opportunity to **efficiently deploy 5G networks.**
- A **$50B/yr** opportunity to **reduce corporate overhead.**
- A **$30B/yr** opportunity to **engage customers in new ways.**

And from the balance sheet:

- A **$375B** opportunity to **use spectrum more efficiently.**
- A **$350B** opportunity to **use physical assets more efficiently.**
- A **$45B** opportunity to **drive value to customers in new ways.**

Where Are The Biggest Opportunities?

The nature of exponential growth makes emerging categories look deceptively small. When investors dismiss DeWi today, it's driven by the same thinking that led investors to pass on Coinbase ("there's already Bitcoin—how many cryptocurrencies can there really be?"), Salesforce ("there's already CRM—how many SaaS products can there really be?"), and Shopify ("there's already Amazon—how many e-commerce stores can there really be?").

Fast forward to today, and Salesforce has acquired 70+ SaaS companies (out of >25K), Coinbase lists 215+ tokens (out of >20K), and Shopify supports 1.75M+ e-commerce business (out of >10M). And it's not that these companies are sole winners in their markets: there's dozens of other SaaS businesses, crypto-networks, and e-commerce brands valued at billions of dollars. Meanwhile, investors stuck on "how many can there really be?" missed out on category-leading businesses behind some of the most pivotal technology trends of the past decade.

Which begs the question: what's the form factor of DeWi, analogous to a SaaS business / e-commerce store / token issuer?

Mobile hybrid network operators (MHNOs) & wireless internet service providers (WISPs).

> 💡 ***In both cases, DeWi gives entrepreneurs the tools to experiment with new products and customer segments at a fraction of the historical fixed costs. MVNOs, who traditionally need to charge $45-60/mo to breakeven on data costs, can now achieve the same charging $15-20/mo. WISPs, which have traditionally needed 1K+ customers to amortize the cost of a single fiber backhaul connection, can now operate profitably with <100 customers.***

MVNOs

Telcos spend $80B/yr marketing and managing their networks. But with revenue growth of <2%, investors are not seeing the benefits. With an average NPS of 6 (compared to 20+ for large banks and 30+ for payments networks), customers are not seeing the benefits either. The real winners are telco executives, who got paid >$60M in 2021 while shareholders lost more than $30B under their stewardship.

Given the astronomical capital and regulatory requirements to build a new telco, the only real option for entrepreneurs has been to build MVNOs. In an attempt to differentiate, most MVNOs target niche audiences (e.g., Latinos, conservatives, seniors) or leverage existing brands (e.g., Disney, ESPN, MTV). However, virtually all MVNOs fall short of venture-scale outcomes because - regardless of their structure - they ultimately rely on renting wholesale network access from telcos. Even crypto-esque connectivity-sharing MVNOs, which found product-market fit over a decade ago, were inevitably thwarted by telcos.

It's a tale as old as time: if you buy your inputs from a competitor, any progress is quickly offset by rising wholesale prices. MNOs generally charge $3-4/GB wholesale, but can sometimes charge as much as $10/GB. Given the average American uses 15 GB/mo of mobile data, MVNOs need to charge $45-60/mo just to break even on data transfer ($150/mo in the extreme case) — before the cost of acquiring and servicing customers.

The only companies to make the MVNO model work have been cable operators: Comcast, Charter, and Altice. These companies amassed 9M mobile subscribers (+40% YoY) with a super long runway for growth (9M subs is still <10% of their broadband subscriber base). How is it possible that they are succeeding at a consumer-facing business after Disney/ESPN/MTV failed? It's because, unlike the media brands, cable operators can route mobile traffic onto their own backhaul networks at near-zero marginal cost. They manage to offload 60-80% of total traffic this way, massively cutting down on the $3-4/GB fees traditionally paid to telcos.

By being the first low-cost & credibly-neutral offload partner, DeWi networks will change the fundamentals of the MVNO business. At the price charged by Helium/Pollen ($0.50/GB), MVNOs who offload 60-80% of traffic only need to charge $15-20/mo to breakeven on data transfer (vs $45-60 historically). Furthermore, certainty in the cost structure will help make MVNOs investable for venture capitalists and other pools of risk capital.

DeWi adds an important nuance to the MVNO business: location. MVNOs whose customers reside in areas with plentiful DeWi coverage can offload larger portions of their traffic at cheaper rates. The table below shows how, by leveraging cheap DeWi offload and using token rewards to drive customer acquisition, MVNOs can generate unit economics that are competitive with incumbent telcos while requiring far less capital.

Marginal Costs					
		MVNO			
	MNO	Cable	DeWi-Strong	DeWi-Weak	Standalone
Marginal Cost of Data Transfer (per GB) on MNOs	$0.05	$2.50	$2.50	$2.50	$2.50
% of Volume Offloaded at Low Cost	*0%*	*80%*	*70%*	*25%*	*0%*
Marginal Cost of Data Transfer (per GB) on DeWi	–	$0.05	$0.50	$0.50	–
Blended Marginal Cost per GB	**$0.05**	**$0.54**	**$1.10**	**$2.00**	**$2.50**
(x) Avg Per-Capita Data Transfer (GB/mo)	20	20	20	20	20
Monthly Marginal Data Costs Per User	**$1**	**$11**	**$22**	**$40**	**$50**

Unit Economics					
		MVNO			
	MNO	Cable	DeWi-Strong	DeWi-Weak	Standalone
Monthly Sticker Price	**$75**	**$75**	**$75**	**$75**	**$75**
(-) Data Costs	($1)	($11)	($22)	($40)	($50)
(-) Servicing Costs Per User	($15)	($15)	($15)	($15)	($15)
MVNO Gross Profit	**$59**	**$49**	**$38**	**$20**	**$10**
(+) Contribution from Other Services	–	$15	$5	$5	–
Gross Profit	**$59**	**$64**	**$43**	**$25**	**$10**
(%) Monthly Churn	1.0%	0.5%	2.5%	2.5%	2.5%
LTV	**$6,232**	**$13,197**	**$1,969**	**$1,145**	**$458**
(%) CAC	$900	$900	$300	$300	$900
LTV / CAC	**6.9x**	**15x**	**6.6x**	**3.8x**	**0.5x**
Gross Margin	*79%*	*86%*	*57%*	*33%*	*13%*

Source: Escape Velocity research

We are excited about two types of businesses: MHNOs and MVNO enablers.

MHNOs

Mobile Hybrid Network Operators, or MHNOs, describes a new class of MVNO business models leveraging DeWi rails to supercharge their unit economics. For example, we think an MHNO targeting coastal tech / finance employees could be extremely profitable:

- **1) Customers have a high willingness to pay for ancillary services.** Customers have disposable income, no car bill, and are used to paying for digital services. Additionally, 98% of employers have some form of cell phone reimbursement, which eliminates consumer price sensitivity. MHNOs could potentially even bundle health-related services, enabling them to capture a portion of tax-advantaged FSA / HSA spend. MVNOs like Efani or Cloaked Wireless, who offer $75-100/mo cell plans with enhanced privacy/security protection, could be first-movers in this market.
- **2) Customers are concentrated in cities with strong DeWi coverage.** Both Helium and Pollen networks are concentrated in major US cities (e.g., NYC, SF, LA, Houston, Miami), which are also cities with high concentrations of early tech adopters. If an MHNO can offload 80% of traffic and breakeven on data transfer at $15-20/mo, the average cell phone plan of $125/mo leaves plenty of room for companies to find ways to share

value back with customers. Because DeWi networks are permissionless, well-capitalized MHNOs can deploy radios directly in areas with the highest offload costs — their gross margins are finally in their own hands.

- **3) MHNOs will earn token rewards from using DeWi networks.** Pollen eSIMs currently earn 3.4% of network rewards (~$50K/mo); other DeWi networks are likely to follow with their own demand-side incentives. MHNOs can choose to share these tokens with customers to lower acquisition costs and increase engagement; or use tokens to subsidize lower headline costs for customers; or hold tokens on balance sheet, becoming a hybrid MHNO-mining business; or donate the tokens to open-source development communities; or invent any number of new ways of delivering value to their customers.

Coastal tech/finance employees are by no means the only demographic where this playbook applies. We see DeWi sparking a renaissance of the MVNO model, enabling the creation of thousands MHNOs across the US. Most of these businesses will build in niche and/or competitive markets, but a few will build outsized companies with lasting brands. We're excited about MHNOs that find ways to build defensible brands by delivering value to customers in a unique way.

How big can these businesses be? Revolut, when it launched in 2015, was a debit card with fee-free FX transactions. At the time, it would have been difficult to predict what the Revolut app looks like today: physical cards, virtual cards, bill payments, equities trading, crypto trading, insurance, travel, e-commerce, and more. As Revolut (and Robinhood, Venmo, Cash App, and many others) have proved, building direct, trusted digital relationships with consumers can be massively valuable.

It's similarly difficult to predict the ways creative entrepreneurs will monetize the MHNO model. However, we can estimate the size of the prize based on monthly gross profit per user and a 5x valuation multiple, which suggests a path to a $10B+ opportunity. Cellular connectivity - with an monthly ARPU of $75-125 and a product customers use nearly 24/7 - is as good a place as any to anchor a consumer brand.

Enterprise Value ($B) @ 5x Gross Profits						
		Number of Customers (M)				
		0.5	1.0	2.5	5.0	25.0
Monthly Gross Profit Per User ($)	$5	$0.2	$0.3	$0.8	$1.5	$8
	$10	$0.3	$0.6	$1.5	$3.0	$15
	$20	$0.6	$1.2	$3.0	$6.0	$30
	$50	$1.5	$3.0	$7.5	$15	$75

Paths to building a venture-scale MHNO business.

The market is already seizing the MHNO opportunity. US Mobile, a tech-first MVNO with a flexible mix-and-match platform, grew its way into $30M of ARR while raising only $4M seed round (talk about capital efficient!) - they recently raised another $30M to further accelerate growth. Within the Helium community, there are rumors of an upcoming MHNO launch from Nova Labs.

MVNO Enablers

The second class of businesses we are excited about do exactly what they say: enable MVNOs. Today, integrating with a telco costs $50K+ in up-front implementation fees plus a host of bureaucratic red tape. Companies abstracting away the cost/complexity of these integrations have been around for a long time, called MVNA/MVNEs, but always as services-first, not software-first businesses; and like most services businesses, they have produced mediocre outcomes for investors.

But if the number of MVNOs grows 10x, there's a clear opportunity to build products for the coming wave of new entrants that will eventually represent 90% of the market. For example, Oxio offers an MVNO-in-a-box platform that enables any business with a captive customer relationship (e.g., retailers, fintechs, consumer apps) to become an MVNO. The idea has been tried in the past, but seems to be hitting its stride: Oxio serves many of largest consumer brands in Mexico and recently raised $40M to expand to the US and Brazil. If thousands of challenger MVNOs launch in the coming years, companies like Oxio or Gigs will have a path to making a multi-billion dollar businesses out of 'arming the rebels'.

How big can these businesses be? There are ~200 MVNOs in the US today, a number which we think can grow to 3K+ by the end of the decade. If MVNOs collectively take 1/3rd of telcos' market share (100M customers or $90B ARR), then an MVNO enabler with a 5% revenue take rate has a $4.5B+ revenue opportunity (see LHS below). This is likely to be shared amongst multiple companies as the infrastructure needs of various customer verticals diverge over time. A 5% take rate feels reasonable relative to where MVNOs sit in the stack - in fintech terms, roughly halfway between a payments processor (2-3%) and an insurance TPA (7-8%).

Derivative markets for bandwidth are a venture-scale opportunity onto themselves (see RHS below). Since derivatives generally trade 3x+ higher volumes than spot markets, telco revenues of $270B could mean that even at small take rates (5 bps) there is an opportunity to build a huge derivatives business - $400M+ revenues - on top of a global payments network for bandwidth.

Enterprise Value ($B) @ 5x Revenues

MVNO Enabler Revenue Take-	Total MVNO % Market Share				
	1%	5%	10%	33%	50%
2.5%	$0.3	$1.7	$3.4	$11	$17
5.0%	$0.7	$3.4	$6.8	$23	$34
7.5%	$1.0	$5.1	$10	$34	$51
10%	$1.4	$6.8	$14	$45	$68

Paths to building a venture-scale MVNO enabler business.

Internet Service Providers

Telcos spend $50B/yr deploying 5G networks, and yet despite the massive investments, they struggle to sufficiently densify their networks in the face of data transfer demand compounding at >30%. First, telcos openly admit to deploying 5G coverage only in dense urban areas: if your town doesn't have an NFL team, you're out of luck. Second, even in the so-called NFL cities, incumbents struggle to deploy small cells profitably: the leading player, Crown Castle, spent tens of billions of dollars deploying 115K+ small cells, only to earn notoriously disappointing returns on capital (13% vs 20%+ on towers).

At a high level, there are three ways to provide last-mile internet access. 100M+ American households get their internet via physical wires, made of either fiber/copper and deployed either above/under-ground. These wired connections provide the best speed / capacity and don't require spectrum, but are capital intensive to deploy. 10M+ American households get their internet from radio waves transmitted through terrestrial antennas, typically placed either on towers or other buildings; this method requires far less capital, but the connection is slower, less reliable, and requires spectrum. Lastly, 2-3M American households get their internet from radio waves transmitted by antennas on satellites, which can be geo-stationary or low-earth orbiting. Satellite internet is the worst in terms of performance (because signals have to travel >1200 miles each way), but is often the only feasible choice for rural communities.

Wireless Internet Service Providers, or WISPs, fall into the middle category: they install a radio wave antenna on your house, point it towards a bigger antenna on the nearest cell phone tower, and rent backhaul capacity from the fiber on that tower to provide internet access. The typical WISP is a small business with 10 employees, 2K customers, and $1-2M of annual revenues. These businesses are often federally-subsidized, including by the $65B earmarked for broadband in the Infrastructure Investment and Jobs Act.

Like MVNOs, prior attempts at scaling WISPs have resulted in unenviable outcomes for investors. Clearwire - a company founded in 2002 by telco legend Craig McCaw - raised $3.4B for its fixed wireless and grew to 200K subscribers, but made some regrettable architecture choices (WiFiMax > LTE), never reached profitability, and eventually sold to Sprint for the same amount as it raised; Starry - a fixed wireless provider using mmWave spectrum founded in 2014 - raised $250M+, grew to 50K subscribers, and SPAC'd at a $1.6B valuation earlier this year, only to miss their growth projections and see the stock price fall >75%; Shentel - a cable company with 100+ years of experience - tried and publicly failed to build a profitable WISP business, which they are now in the process of shutting down; Tarana - a hardware company that builds specialized non-line-of-sight radios for fixed wireless - raised $495M, filed 25+ patents, and took twelve years to reach $10M in quarterly revenues; Cradlepoint - another fixed wireless hardware company - raised $205M and sold to Ericcson for less than $10M. We're not saying these are bad companies or poorly-executed ideas: just that the WISP business has been exceptionally hard to make money on.

Similar to the dynamic in MVNOs, the only truly successful entrants into the WISP business have been incumbents: not cable operators, but telcos. In part to strike back at cable MVNOs stealing their mobile subscribers, the big telcos launched WISP businesses that have amassed 2M+ subscribers across T-Mobile + Verizon + AT&T. The former two are leaning into the model, promising shareholders that their fixed wireless subscriber base will grow to 11M+ by 2025. AT&T is instead focusing on extending its fiber footprint, with the rationale that customers prefer fiber's lower latency over fixed wireless (Verizon points to the fact that their own fiber customers almost never use its full capacity).

How is it possible that T-Mobile/Verizon/AT&T succeed at scaling their WISP businesses when every prior attempt - including those with plenty of funding, industry expertise, hungry entrepreneurs, and differentiated technology - have all failed? Captive customer bases certainly help, but it hasn't guaranteed success for telcos launching new products in the past. *The real unfair advantage is the hundreds of billions of dollars of radios that telcos have already deployed on towers.* So long as there's spectrum available, telcos have near-zero incremental capex or opex from an incremental fixed wireless customer, beyond mailing a router to the subscriber's house and customer support. (note: the qualifier is important - spectrum availability is a real problem for fixed wireless, particularly in urban areas with limited capacity; telcos generally self-impose caps on subscribers in dense areas in order to avoid such interference and quality degradation).

By being the first open radio networks at scale with 100% usage-based pricing, DeWi will change the fundamentals of the WISP business. Historically, the fixed costs of a wholesale fiber connection ($3K/mo) have made the traditional WISP business impractical at small scale. At a sticker price of $50/user/mo, a WISP with 100 customers generates 30% gross margins: not a death sentence, but combined with a customer acquisition costs of $450/user fully-loaded, it means the business is barely staying afloat (1.5x LTV/CAC). However, at scale of 1K+ subscribers and with strong user retention to offset acquisition costs, WISPs can deliver strong unit economics of >4x LTV/CAC (for an excellent, more granular view on the unit economics of a WISP, see Althea's sustainable networks).

DeWi unlocks two levers for WISPs: 1) in areas where WISPs deploy their own radios, DeWi networks are "buyers of last resort" for excess capacity; 2) in areas where deploying radios is too capital intensive, WISPs can rent backhaul from DeWi networks on a per-GB basis (i.e., by burning governance tokens in a burn-and-mint model). These two unlocks will allow WISPs to operate profitably at any scale by removing the fixed cost barrier in markets with DeWi coverage.

	Traditional WISP		DeWi-Native WISP
	Subscale	At Scale	Subscale & At Scale
Number of Customers	100	1,000	100
Unit Economics			
Monthly Sticker Price	$50	$50	$50
(-) Backhaul Costs	($30)	($3)	($3)
(-) Customer Support	($5)	($5)	($5)
(+) DeWi Mobile Offload	–	–	–
Monthly Gross Profit	$15	$42	$42
(%) Monthly Churn	2.5%	2.5%	2.5%
LTV	$687	$1,924	$1,924
(+) Y1 DeWi Mining Rewards	–	–	$50
Adjusted LTV	$687	$1,924	$1,974
(+) CAC	$300	$300	$300
(+) Installation Costs	$150	$150	$150
Fully-Loaded CAC	$450	$450	$450
Adjusted LTV / CAC	**1.5x**	**4.3x**	**4.4x**
% Gross Margin	*30%*	*84%*	*84%*

Source: Escape Velocity research

We are excited about two kinds of businesses: Venture Miners & WISP Enablers.

Venture Miners

DeWi miners are businesses that deploy networking equipment and provide internet connectivity to mine tokens. Not all DeWi miners fit the Venture Miner definition — in fact, most don't. There are many ways to build a DeWi mining business: which networks should you mine? which locations should you focus on? should you own vs rent property? what about equipment? should you use contractors or employees? how much debt should you take on?

DeWi adds a special nuance to crypto mining business: location. In general, markets will treat miners that *own* their locations like tower REITs: high-yielding assets that have traded at >5x book value for the past decade (currently 10-15x). On the other hand, miners that *rent* property will be treated like Bitcoin miners: they may have advantaged access to a key mining resource in the near-term, but they don't get credit for owning it long-term. Bitcoin miners trade in a tighter range around 0.5-2.5x book value (although they did reach 10-15x multiples during the height of the 2021 bull market).

Like Bitcoin miners, DeWi miners are doomed to face the eternal question from equity investors: why shouldn't we just buy Bitcoin/Helium tokens directly? From a valuation perspective, miners have a cost of capital denominated in BTC/HNT, currencies which have been incredibly difficult to outperform over long periods of time. Despite this being true, we believe that - under the right circumstances and with the right team - DeWi mining can be a venture-scale business while also providing diversified exposure to the entire DeWi category. We call the strategy *Venture Mining,* a model pioneered by Hexagon Wireless.

The goal of venture mining is to maximize the value of DeWi tokens on balance sheet in the most capital efficient manner possible. Because networks tend to reward early miners generously (i.e., Helium / Pollen distribute 11% of their max supply to miners in the first year), those who are earliest to networks stand to earn outsized token rewards relative to the amount of fiat capital invested. What separates Venture Miners from regular miners is *speed,* which leads to *scale*.

Miners face a choice of which DeWi network(s) to spend their time and resources mining. Ceteris paribus, venture miners prefer DeWi tokens that:

- **1) Are early in their development**, to maximize available rewards
- **2) Have little competition,** to maximize share of available rewards
- **3) Have the brightest long-term prospects,** and/or near-term liquidity

- **4) Have price stability,** to maximize fiat rents and/or leverage

How big can these businesses be? Marathon Digital, the largest publicly-traded Bitcoin miner which was started in 2010, has 10K BTC on its balance sheet (5 bps of the Bitcoin network). The average Pollen flower is currently earning 100K PCN on an annualized basis, or 1 bp of the Pollen network. We suspect there are multiple mining operations with close to 100 flowers deployed, suggesting there are miners out there who already own 1%+ of the Pollen network on a fully-diluted basis.

Venture Miner - Tokens on Balance Sheet ($B)						
		DeWi Market Cap ($B)				
		$1	$10	$50	$100	$250
Total Network Ownership	1.0%	$0.0	$0.1	$0.5	$1.0	$2.5
	2.5%	$0.0	$0.3	$1.3	$2.5	$6.3
	5.0%	$0.1	$0.5	$2.5	$5.0	$13
	7.5%	$0.1	$0.8	$3.8	$7.5	$19

Paths to a venture-scale DeWi mining business.

The best venture miners will build moats that extend beyond the value of their balance sheets and garner valuation of several times book value. On a 2-3 year time frame, DeWi mining will feel like Bitcoin mining, and the keys to success will be the same: in the words of the world's biggest Bitcoin miner, Be Agile, Get Big. On a 5-10 year time frame, as proof-of-coverage rewards are replaced by data transfer and the winning DeWi networks become entrenched, venture miners will feel less like Bitcoin miners and more like tower REITs.

The real TAM of DeWi mining is *the total unrealized value of real estate that could be used more productively by hosting networking equipment*. Venture miners will find ways to capture an outsized share of this value creation by signing long-term leases on high-value properties, or even buying them outright. Once at scale, venture miners are well-positioned to expand up the value chain by serving customers directly, adopting a hybrid MHNO-miner or WISP-miner model.

WISP Enablers

The second type of business we are excited about, WISP enablers, build tools to help deploy and optimize wireless networks. Recall that thanks to DeWi, a WISP with 10 customers can have the same unit economics as a WISP with 1000 customers, enabling the creation of tens of thousands of WISPs over the next decade. Software platforms that enable this emerging set of WISPs, as well as other types of DeWi miners, have a long runway for growth.

Hotspotty, for example, offers a full-stack software platform where can miners plan, monitor, and manage their fleets. As DeWi miners scale from tens to hundreds to thousands of radios, operations become exponentially more complex and the value of an integrated software platform grows accordingly. Mining businesses tend to be run by networking / systems engineers who lack the internal capabilities to build specialized fleet management software. This creates an opportunity for companies like Hotspotty or Weaver Labs to build high-quality, shared software infrastructure for the entire DeWi ecosystem.

Beyond the SaaS model, there are many potential approaches for ISP enablers. Companies like Airwaive and Sitenna are taking a marketplace approach, aggregating hosts, miners/ISPs, and networks on three-sided marketplaces. Gamified approaches, such as Anthomaniacs by Hexagon Wireless, have the potential to bring DeWi to a mass market audience. ISP-in-a-box platforms, which have been tried unsuccessfully in years past, may finally get their time in the sun. Financing models, like "rent-to-own your own WISP", are sure to be explored. The problem statement for all of these businesses is the same: how do we help miners/WISPs build and operate wireless networks? Software, marketplaces, games, and financing are all potential answers to this question. We believe the

number of WISPs will grow from 2-3K to 20-30K by the end of the decade, driving an opportunity for a $10B+ infrastructure business.

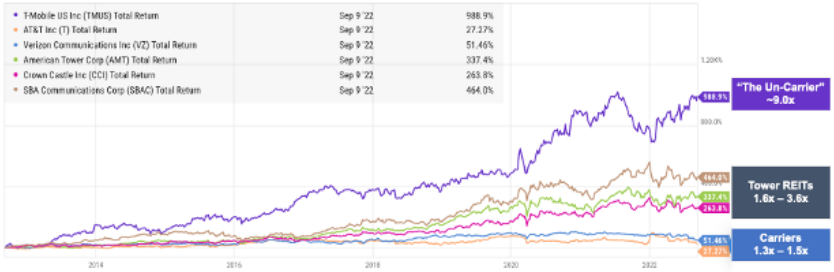
ISP Enabler - Enterprise Value ($B) @ 10x Revenue						
		Number of ISPs (K)				
		3	5	10	25	50
Monthly Revenue per Customer ($)	$500	$0.2	$0.3	$0.6	$1.5	$3.0
	$1,000	$0.4	$0.6	$1.2	$3.0	$6.0
	$2,500	$0.9	$1.5	$3.0	$7.5	$15
	$5,000	$1.8	$3.0	$6.0	$15	$30

Paths to a venture-scale ISP enabler business.

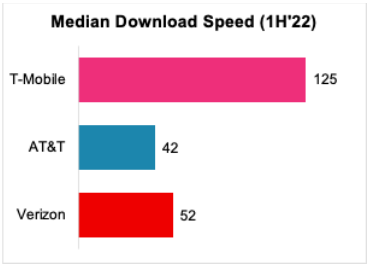
Unlocking Capital Efficiency

Telcos have a history of 1st-party to 3rd-party infrastructure transitions. Most notably, telcos used to own towers, but sold them off to REITs over the past decade. Perhaps most famously, in 2012 John Legere sold T-Mobile's tower portfolio to Crown Castle seven days after becoming CEO. The rationale was simple: a tower with three tenants earns 8x higher returns on capital than a tower with one tenant (see page 18). The proceeds allowed T-Mobile to invest in building the leading 4G LTE network in the country (and in the case of VZ/AT&T, selling towers reduced leverage and protected their investment-grade credit ratings).

Shared infrastructure is simply more efficient: the same towers that were sold by the telcos at $0.4-0.5M/tower are now valued 3-5x higher in the public markets ($1.5-2.0M/tower). This shows the power of credibly-neutral shared infrastructure: by extricating tower ownership away from telcos, towers became more productive assets, generated higher yields, and were valued at higher multiples by investors, ultimately leading to >$100B in value creation. The bulk of this value was captured by tower REITs (by increasing tenants-per-tower and raising rents) and challenger telcos like T-Mobile (by freeing up their capital to invest more heavily into radio networks and marketing).



Source: indexed 10-year total shareholder return from yCharts.

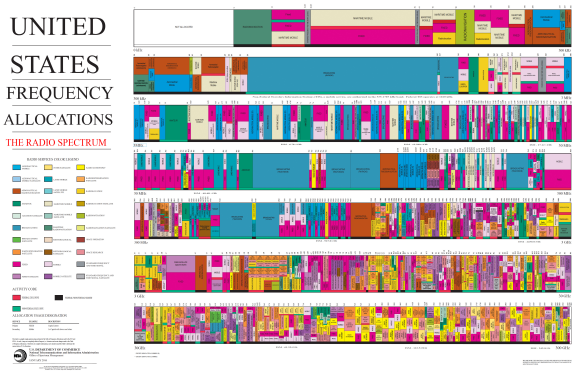


Source: RootMetrics

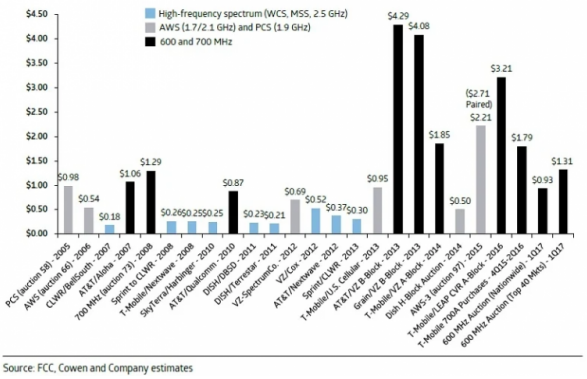
Telcos sold off the vast majority of their tower portfolios over the past decade, but their $1T balance sheet remains overburdened with other types of underutilized assets, namely spectrum.

Spectrum licenses are permission from the government to transmit radio waves over a certain frequency and in a certain location. These licenses often come with restrictions (e.g., power limitations) and/or covenants (e.g., buildout requirements). Three things to note about spectrum licenses: 1) spectrum coordination is highly complex/fragmented (see LHS below), 2) the value of licenses can vary dramatically, but can be worth as much as $2-4 per MHz-person

(see RHS), and 3) licenses are sold at government auctions where regulators set the rules and unilaterally control who gets to bid. In total, the FCC has sold $230B+ of spectrum which is currently valued at $375B+ on telco balance sheets.



Source: Visual Capital



Source: IEEE

Like towers, spectrum is more efficient when shared. In today's version of telcos, the chronology for deploying networks is: 1) buy spectrum licenses at an FCC auction, 2) deploy radios that are compatible with the specific band of spectrum, 3) wait for consumers to buy phones that are also compatible, 4) test the network for reliability and quality of service, and 5) only then can telcos transfer live customer data over the acquired spectrum. Steps #2-4 can take years during which spectrum licenses are sitting idly on telco balance sheets earning zero return.

It's not clear exactly what percentage of spectrum is productively used, but it's clear that spectrum is massively underutilized. MVNO Leap Wireless disclosed in 2012 that 60% of its spectrum went unused at any given time. Qualcomm executives estimate 30% of spectrum in India went unused in 2019. Given that telcos hold $375B of spectrum to generate $270B of revenues, reducing the amount of balance sheet spectrum by 30-60% would drive an increase in telco's return on equity from 12% to 15-20%. This may seem like a relatively small increase, but in nominal terms implies >$100B of value creation for consumers and shareholders.

Spectrum sharing is far from a new idea. Doug Hutcheson, the CEO of Leap Wireless, has been calling for it for over a decade. The EU has been researching it for a long time, but - in typical European fashion - moderately-successful local initiatives have failed to turn into a coherent EU-wide standards. However, the most interesting developments in spectrum sharing are happening right now in America. And - in typical American fashion - it's a tale of unabashed capitalism, and unabashed litigation.

First some background: in 1963, the FCC allocated 195 MHz of spectrum to a program called EBS, or Educational Band Spectrum. This spectrum was given to universities/schools in chunks of 35-mile radius, with the intent that they broadcast educational content on TV for their local communities. As you might guess, there was no demand for locally-produced educational television, and most EBS spectrum was rarely if ever used. By the 1970's, the FCC acquiesced and began allowing schools to lease their licenses to earn yield. Fast forward to today and 93%+ of EBS licenses are leased to singe telco: T-Mobile. In 2020, alongside a host of spectrum initiatives, the FCC passed a new rule allowing schools to not only lease, but also *sell* their EBS licenses—including those leased to T-Mobile.

Enter WCO Spectrum, a new company led by telco legend Gary Winnick (who financed the first privately-owned undersea fiber cables in the '90s), who claims that 7% of all EBS licenses have already traded hands, presumably acquired by either WCO or T-Mobile.

When WCO acquires a license, they effectively become T-Mobile's spectrum landlord. Lease terms are up to 30 years, after which WCO can raise rents, lease the spectrum to competing telcos, or even deploy their own radio

network. This is a huge, huge problem for T-Mobile, because the 2.5GHz spectrum is a bedrock of their 5G strategy - they already use it to cover 200M+ Americans, expected to increase to 300M+ by year-end 2023.

To secure this spectrum, T-Mobile is turning to aggressive litigation. Their lawyers threatened to sue schools and universities if they disclosed the terms of T-Mobile's leases to any third parties (i.e., potential buyers). T-Mobile is actively engaged in lawsuits in at least two cases, claiming the lease terms are "trade secrets" and that <75 internal employees have access to the information. It goes without saying, without disclosing lease terms there's little hope for schools to get fair market value for their licenses.

The story is so absurd it is best illustrated by example. Christian's College of Georgia (CCG, an institution founded in 1947 to train future Christian ministers based out of Atlanta suburbs, leases its EBS licenses to T-Mobile for $55K/yr. This funding provides half of the school's total funding. Given a population of roughly 250K+ within the 35-mile radius around Athens, we estimate the annual spectrum rent paid by T-Mobile is 4-5 cents per MHz-pop.

After the FCC ruling, T-Mobile offered the school $1M to buy the licenses, representing an 18x multiple of the current annual rent (5.5% yield or $0.80 per MHz-pop). The newly-capitalized WCO offered $5.5M, representing a 100x multiple of current annual rent (1.0% yield or $4.40 per MHz-pop). The lease in question expires in 2038, at which point WCO would be able to aggressively raise T-Mobile's rent, auction off the spectrum to other carriers, or split the spectrum up into pieces and sell/lease it in parts: in other words, fulfill its mission of "maximizing value for EBS spectrum license holders". In practice, this likely means WCO will follow in towers' footsteps and structure a REIT that provides public markets access to a diversified portfolio of spectrum assets in a tax-advantaged manner. Follow Linda Hardesty (of Fierce Wireless) and Mike Dano (of Light Reading) if you're interested in how the situation unfolds.

It's hard to overstate the size of the spectrum sharing opportunity. The three big tower companies have $120B+ of assets and $230B+ of market cap… spectrum licenses are worth $375B+ *in the US alone*. In the example above, WCO can afford to pay 5.5x more than T-Mobile for the same license and still make money over the long-term by raising rents and/or partitioning the spectrum to multiple carriers. Assuming a credibly-neutral landlord can increase cap rates from 5.5% → 25% (for comparison, tower portfolios went from 3% → 24%) and assuming the market values spectrum REITs similar to tower REITs (at 2% equity yields), WCO can more than double their money over 16 years. A 5% IRR might seem unexciting to retail investors, but for investors who can - and in fact, need to - put billions of dollars into each trade, the opportunity to compound billions of dollars at >5% over decades, with real-estate-like downside risk protection, plus upside exposure to technology trends, doesn't come around very often.

	2022	2038	Growth Multiple
Book Value of Spectrum	$1,000,000	$1,000,000	–
(x) Cap Rate	5.50%	25.00%	4.5x
Annual Rent	$55,000	$250,000	4.5x
(%) Yield at Market Price	1.00%	2.00%	2.0x
Market Value	**$5,500,000**	**$12,500,000**	**2.3x**

DeWi networks will tokenize spectrum, fulfilling the true vision of shared spectrum. Spectrum REITs *create value by extracting value:* they raise rents up to the fair market rent. Tokenized spectrum *creates value by unlocking value:* in addition to raising rents up to the fair market rent, *tokenizing spectrum increases utilization by bringing*

transaction fees to zero. One user can rent spectrum for a few hours and another can rent the same spectrum hours - or even seconds - later.

The technology needed to achieve tokenized spectrum is quarters, not years away: teams like SuperDAO, KaliDAO, and Seed Labs are creating products to spin up on-chain investment entities in the click of a button, abstracting away 50+ hours of backend legal work. KlimaDAO (carbon credits), Centrifuge (debt/receivables), and orebits (gold) have already tokenized $100M+ of real world assets. Federated Wireless - an FCC-registered spectrum administrator for the CBRS band - has already registered >3K outdoor small cell deployments on behalf of Helium and Pollen miners into FCC databases.

The nice thing about spectrum tokenization is that it doesn't require tons of startup capital to experiment with: a natural place to start is to tokenize CBRS priority access licenses, which can be purchased for as little as tens of thousands of dollars (<0.1% of the $47M raised by ConstitutionDAO). Licenses could then be shared by DeWi networks that rent access on a block-by-block basis. Given the structure of PALs (i.e., free unlicensed spectrum with paid priority tiers), DeWi networks operating in CBRS spectrum will eventually resemble post-London Ethereum with a "base fee" paid in network tokens (HNT/PCN) and a "priority fee" paid in spectrum tokens.

Abstraction layers will need to be built for old-school telcos to interact with tokenized spectrum licenses. Companies like Select Spectrum are building platforms to streamline CBRS transactions which will, over time, be interfaces that connect users to deep pools of on-chain liquidity. Spectrum tokenization is a nascent area of DeWi, but could happen faster than you think: in the voluntary carbon credit markets, KlimaDAO tokenized 1-2% of global supply in its first few months post-launch.

How big can these businesses be? We consider two approaches to size the opportunity for tokenized spectrum. On the left hand side, we assume that 5-25% of the $375B of spectrum is currently unused and can be unlocked by tokenization, with the company/protocol enabling it earning a take-rate of 2.5% to 20% of value created. On the right hand side, we assume 10-100% of all spectrum is tokenized, and that the enabling company earns a gross annual fee of 5-50 bps, valued at a 10x revenue multiple. Both approaches come to similar conclusion: there's a $10B+ opportunity to tokenize spectrum assets.

Spectrum Tokenization - Enterprise Value ($B)						
		% of Unused Spectrum Unlocked				
		5%	10%	15%	20%	25%
% Take Rate of Value Created	3%	$0.5	$0.9	$1.4	$1.9	$2.3
	5%	$0.9	$1.9	$2.8	$3.8	$4.7
	10%	$1.9	$3.8	$5.6	$7.5	$9.4
	20%	$3.8	$7.5	$11	$15	$19

Spectrum Tokenization - Enterprise Value ($B)						
		% of Total Spectrum Tokenized				
		10%	25%	50%	75%	100%
Annual Fees (bps)	5	$0.2	$0.5	$0.9	$1.4	$1.9
	10	$0.4	$0.9	$1.9	$2.8	$3.8
	20	$0.8	$1.9	$3.8	$5.6	$7.5
	50	$1.9	$4.7	$9.4	$14	$19

Fin

The emergence of DeWi networks has us excited about five types of businesses: MHNOs, MVNO enablers, ISP enablers, Venture Miners, and Tokenized Spectrum. These businesses are tackling multi-billion markets and - beyond their own success - will enable tens of thousands of American small businesses to thrive. Thanks to DeWi, we will finally have communications infrastructure that is more competitive, efficient, private, reliable, and inclusive than today's networks.

As for the incumbent telcos and their shareholders, we'll leave them with our latest artistic work*:*

Moats of a Telco (2022)