Northwest **Power** and **Conservation** Council

September 5, 2018

MEMORANDUM

TO: **Power Committee**

FROM: **Massoud Jourabchi**

SUBJECT: **Impact of Bitcoin Mining on Northwest Electrical Load**

BACKGROUND:

Presenter: Massoud Jourabchi, Manager Economic Analysis
Devin Bates, Portland State University
Mr. Christopher Tamarin, Telecommunication Strategist, Oregon Business Development Department

Summary: Cryptocurrency in general and Bitcoin can be energy intensive. Council has conducted a survey of utilities to identify their cryptocurrency related loads. Current survey does not indicate a large load at regional level. Presentation will present a high-level review of bitcoin mining and will investigate why Northwest is a destination for miner. Mr. Tamarin will present on past telecom investments that has prepared Northwest for Data Center investments.

Relevance: Impact on load

Workplan: NA

Background: Northwest has been a host to many large data centers. A new set of entries have been cryptocurrency miners. Bitcoin mining operations have caused concern for public utilities that have these mining operations in their service area. In this presentation we discussed past and future impact of bitcoin mining on loads. our survey of utilities shows that except for a few utilities, the mining operations do not currently present a major concern, but they may in the future.

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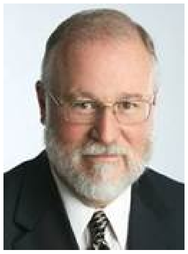
Attachments:
1) Bio of Mr. Christopher Tamarin
2) Brief background on Crypto-currency



Christopher Tamarin
Christopher Tamarin is the Telecommunications Strategist for the Oregon Business Development Department, "Business Oregon," assisting communities with broadband telecommunications infrastructure, applications and public policy. He has seventeen years of experience in marketing voice and data telecommunications services and equipment used in small and large communities by multi-location companies, electric utilities, healthcare providers, schools, and government agencies. He has five years teaching experience at Eastern Oregon University and sixteen years in state government. He has a BS in Business Administration from Elizabethtown College (Pennsylvania), an MBA from the University of Nevada, and an MS in Telecommunications from the University of Colorado.

Background note on Blockchain and Cryptocurrency

This presentation seeks to provide a high-level description of the function and mining of cryptocurrencies as well as their current and potential impacts on utilities in the Northwest. Cryptocurrencies are intended to be transparent and decentralized virtual mediums of exchange. The idea behind virtual currencies became familiar with the invention of debit and credit cards. The difference between the virtual currency in bank and PayPal accounts and those like Bitcoin and Ethereum comes from who regulates and maintains the system of exchange. Some central authority regulates traditional currencies while the members of the system regulate cryptocurrencies. Satoshi Nakamoto wrote the seminal white paper on cryptocurrencies in response to the 2008 financial meltdown, seeking to create a cheap, fast, global, hack-proof, self-regulating financial system that eliminates the need to trust a central authority. In 2009 Nakamoto's brainchild, *Bitcoin*, became the first of the now 1,700 cryptocurrencies offered.

Bitcoin, and others, employ a pre-existing technology known as *blockchain* to track and facilitate currency exchange. Blockchain in its basic form is an electronic ledger. The degree of permission and privacy of a blockchain defines its capability. Bitcoin uses a type of Blockchain that is public and permission-less. So Blockchain and Bitcoin are not synonymous, though blockchains do offer multiple attractive characteristics for cryptocurrencies. A blockchain is also irreversible and its distributed database is monitored by a peer-to-peer network of users or *nodes.* Through encryption it can simultaneously offer transparency and pseudonymity. In the case of Bitcoin, anyone can join, view, and participate in the network while keeping their personal information protected creating a transparent distributed general ledger.

To purchase bitcoins, one must first create a *wallet*, a software program that allows for buying or selling coins. Next, they decide on a purchase amount and an exchange market. Most exchange markets transact with multiple cryptocurrencies. After registering with an exchange, coins can be purchased in a variety of traditional fashions. Finally, coins can be transferred from an exchange to the wallet for future use.

Electricity and Bitcoin intersect via *mining*. Mining is both the process through which *blocks* are validated and added to the blockchain and the mechanism for distributing new coins. To incentivize members of the network to validate transactions new bitcoins are awarded to the miner that adds the next block to the blockchain. A block is a group of hundreds of transactions. A transaction is not finalized until it is added to a validated block, that block is put on the blockchain, and the new version of the blockchain is accepted by the network. Coins are awarded, on average, every ten minutes. The Bitcoin algorithm adjusts validation difficulty to maintain this average. The initial block reward was 50 bitcoins. This reward halves every 210,000 blocks, and currently sits at 12.5.

Validating blocks requires an intense amount of computing power and thus a huge amount of electricity. To validate a block, miner solve extremely difficult math puzzles which can only be done using brute force calculation. The puzzles require users to find inputs that generate specific outputs. The output producing function is completely random, meaning no known pattern exists to match outputs to inputs. Solving a puzzle requires random input guesses until a valid output is produced. The inputs and outputs come in the form of SHA256 hashes, a series of 256 numbers. 2 to the Power 256, an almost humanly incomprehensible number, of possible outcomes exist, and thus miners run hardware dedicated to solving these puzzles all day every day requiring large quantities of constant electricity.

To start mining, miners need a workspace, hard and software, electrical connection, communication connection, and installation to an exchange are required. After that, mining requires very little human labor. Mining occurs in various environments from crawl spaces to large warehouses.

Mining hardware evolved quickly from 2009 to 2014. As miners realized that more computing power meant more coins, they sought methods to improve what is known as the *hash rate,* the number of guesses a unit performs per second. Initially basic CPU units, like the ones in your computer, were used. Quickly, however, miners turned to GPUs or graphics cards as they proved more efficient. Eventually, developers created hardware specifically intended for mining. Today, most miners use ASICs (application-specific integrated circuits) solely dedicated to mining.

Mining's profitability depends on a variety of variable factors including: price of coins, degree of network difficulty, efficiency of equipment, and the price of electricity. Bitcoin's price fluctuated dramatically in the past year, and as more miners join the network the degree of difficulty continues to rise.

Estimates of electricity consumption by the Bitcoin network vary as many utilities are unaware they service miners, though some are discovering mining operations in their service area. A 2017 international research looking into global known mining loads put the total mining load at 500 MWa. Our survey shows that in 2017 the "known" mining load for the Northwest was about 38 aMW. Since the price of Bitcoin peaked in January 2018, a rush of new connect requests poured in, but many of them are not going through as utilities slow down acceptance. To protect ratepayers, many tailor specific term contracts putting the economic risk on miners.

The Northwest attracts cryptocurrency mining for the same reasons it attracted companies like Google and Facebook to put their new data centers here. The regions reliable communication infrastructure coupled with low latency, reliable, ample, cheap, and clean power creates an attractive destination.

As of now, no efficiency standards applicable to mining equipment exist. Cooling of hardware also factors into electricity generation for mines, and HVAC improvements are possible. Additionally, there are some new chip technologies that will reportedly lower energy consumption by 30 percent. However, the current mechanism for adjusting the degree of difficulty for validation in the blockchain, increasing computational requirements works against efficiency in electrical consumption.

Last and not least, we should mention that cryptocurrencies in general, and Bitcoin in particular, are implemented with significant hype, and although original concepts expressed by Satoshi Nakamoto in the nine-page paper introducing a peer-to-peer trustless cryptocurrency system might have been reasonable, the implementation of these concepts have a long-way to go to have public trust and confidence.

Bitcoin Terminologies (adopted from Bitcoin.org and other sources)

Address

A Bitcoin address is **similar to a physical address or an email**. It is the only information you need to provide for someone to pay you with Bitcoin. An important difference, however, is that each address should only be used for a single transaction.

Bit

Bit is a common unit used to designate a sub-unit of a bitcoin - 1,000,000 bits is equal to 1 bitcoin (BTC). This unit is usually more convenient for pricing tips, goods and services.

Bitcoin

Bitcoin - with capitalization, is used when describing the concept of Bitcoin, or the entire network itself. e.g. "I was learning about the Bitcoin protocol today."
bitcoin - without capitalization, is used to describe bitcoins as a unit of account. e.g. "I sent ten bitcoins today."; it is also often abbreviated BTC or XBT.

Block

A block is a **record in the block chain that contains and confirms many waiting transactions**. Roughly every 10 minutes, on average, a new block including transactions is appended to the block chain through mining.

Block Chain

The block chain is a **public record of Bitcoin transactions** in chronological order. The block chain is shared between all Bitcoin users. It is used to verify the permanence of Bitcoin transactions and to prevent double spending.

Confirmation

Confirmation means that a transaction has been **processed by the network and is highly unlikely to be reversed**. Transactions receive a confirmation when they are included in a block and for each subsequent block. Even a single confirmation can be considered secure for low value transactions, although for larger amounts like $1000 USD, it makes sense to wait for 6 confirmations or more. Each confirmation *exponentially* decreases the risk of a reversed transaction.

Cryptography

Cryptography is the branch of mathematics that lets us create **mathematical proofs that provide high levels of security**. Online commerce and banking already uses cryptography. In the case of Bitcoin, cryptography is used to make it impossible for anybody to spend funds from another user's wallet or to corrupt the block chain. It can also be used to encrypt a wallet, so that it cannot be used without a password.

Double Spend

If a malicious user tries to **spend their bitcoins to two different recipients at the same time**, this is double spending. Bitcoin mining and the block chain are there to create a consensus on the network about which of the two transactions will confirm and be considered valid.

Hash Rate

The hash rate is the **measuring unit of the processing power of the Bitcoin network**. The Bitcoin network must make intensive mathematical operations for security purposes. When the network reached a hash rate of 10 Th/s, it meant it could make 10 trillion calculations per second.

Mining

Bitcoin mining is the process of **making computer hardware do mathematical calculations for the Bitcoin network to confirm transactions** and increase security. As a reward for their services, Bitcoin miners can collect transaction fees for the transactions they confirm, along with newly created bitcoins. Mining is a specialized and competitive market where the rewards are divided up according to how much calculation is done. Not all Bitcoin users do Bitcoin mining, and it is not an easy way to make money.

P2P

Peer-to-peer refers to **systems that work like an organized collective** by allowing each individual to interact directly with the others. In the case of Bitcoin, the network is built in such a way that each user is broadcasting the transactions of other users. And, crucially, no bank is required as a third party.

Private Key

A private key is a **secret piece of data that proves your right to spend bitcoins from a specific wallet** through a cryptographic signature. Your private key(s) are stored in your computer if you use a software wallet; they are stored on some remote servers if you use a web wallet. Private keys must never be revealed as they allow you to spend bitcoins for their respective Bitcoin wallet.

Signature

A cryptographic signature is **a mathematical mechanism that allows someone to prove ownership**. In the case of Bitcoin, a Bitcoin wallet and its private key(s) are linked by some mathematical magic. When your Bitcoin software signs a transaction with the appropriate private key, the whole network can see that the signature matches the bitcoins being spent. However, there is no way for the world to guess your private key to steal your hard-earned bitcoins.

Wallet

A Bitcoin wallet is loosely **the equivalent of a physical wallet on the Bitcoin network**. The wallet actually contains your private key(s) which allow you to spend the bitcoins allocated to it in the block chain. Each Bitcoin wallet can show you the total balance of all bitcoins it controls and lets you pay a specific amount to a specific person, just like a real wallet. This is different to credit cards where you are charged by the merchant.

1. 51% Attack

51% attack refers to an attack on a blockchain – usually bitcoin's, by a group of miners controlling more than 50% of the network's mining hash rate, or computing power. The attackers would be able to prevent new transactions from gaining confirmations, allowing them to halt payments between some or all users. They would also be able to reverse transactions that were completed while they were in control of the network, meaning they could double-spend coins.

Impact of Bitcoin Mining on Electrical Load in NW

(Emerging Technology Series)

September 2018

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In this presentation

- What is a cryptocurrency
- Overview of how does it works
- Bitcoin- one currency among 1754 coins
- What is mining for bitcoin means
- Why is it electricity intensive
- Why miners come to Northwest
- How utilities have responded to this load
- Current and future impact on loads
- Opportunity cost of mining

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Genesis of cryptocurrency

- Money as a medium of exchange
  - Central Control (trusted)
    - Gold
    - Paper (gold backed)
- Virtual Currency (cards, PayPal, Amazon cash)
- Financial Crisis of 2007
- Bitcoin: a Peer-to-Peer Electronic Cash System
  - Cryptographic transactions
  - Blockchain (distributed ledger)
- Currently over 1700 coins being offered

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Stated Goals of cryptocurrencies

- No trust required (well almost)
- Fast, cheap, global, no central control (well almost)
- Self-checking
- Prevent double spending
- Hack proof ☺ not at exchange level
- Distributed among users/miners/exchanges through blockchain distributed ledger technology

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Blockchain is not Bitcoin but Bitcoin uses a form of Blockchain

- What is Blockchain Distributed Database
  1. Peer-to-Peer network
  2. Transparency with Pseudonymity
  3. Irreversibility of Records
  4. Computational Logic

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Steps to buy a cryptocurrency (Bitcoin example)

1. Create a wallet
2. Decide how much you want to buy
3. Choose an exchange (market)
4. Register with an exchange
5. Move your coins away from exchange and into your wallet.

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What is mining?
(Where Electricity and cryptocurrency intersect)

- Mining: is validation of transactions in a block.
  - Verifying cryptographed signature of parties and verification of transaction to prevent double spending.
  - Miners operate in tandem or in pools.
  - miners are awarded a portion of bitcoin for their verification as well as a service fee.
- Bitcoin protocol controls the difficulty of mining, so that every 10 minutes a coin is awarded systemwide.

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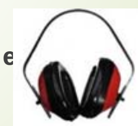
What does it take to start mining ?

- Space to place mining equipment (living room, crawl space, warehouse, a shipping container)
- Mining hard and software
- Electrical connection
- Communication connection
- Install mining equipment and software to an Exchange
- Very little labor is needed

Antminer S9-13TH/s with PSU

- Noise reduction earmuffs highly recommende



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Where can you mine?

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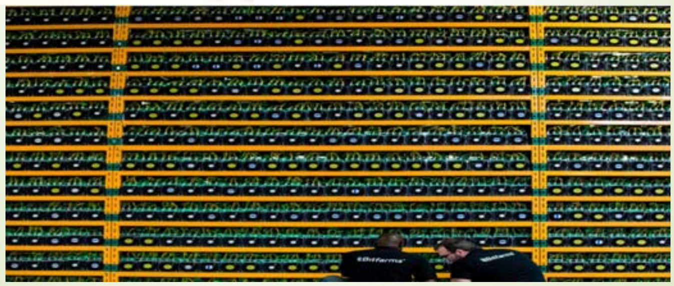

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A normal Residential Meter at 7 am

A Residential Meter with Bitcoin mining operation at 7 am

Video with permission from Chelan PUD

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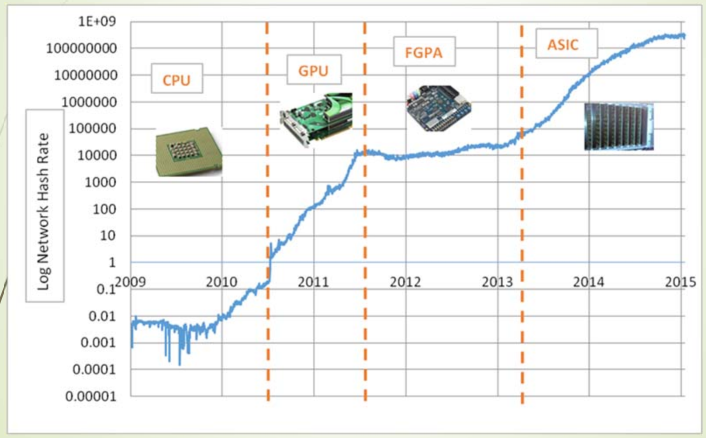
Brief History of Mining Equipment



Cloud Mining

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Profitability of mining depends on

- Computational power of mining operation,
- Degree of Difficulty
- Hash rate
- Bitcoin/USD exchange Rate
- Bitcoin per Block Reward
- Pool Fees %
- Hardware cost
- Power usage of hardware
- Power cost
- Luck

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Relationship between coin price, degree of difficulty and electrical demand

- Price of coins increases
- Mining activity or hash rate increases,
- Number of coins mined increases,
- Degree of Difficulty in the network is increased,
- Electrical consumption for mining increases.
- Degree of Difficulty act as a control on number of coins mined.

Coin price increases → Hash rates increases → Difficulty increases → Electrical demand increases

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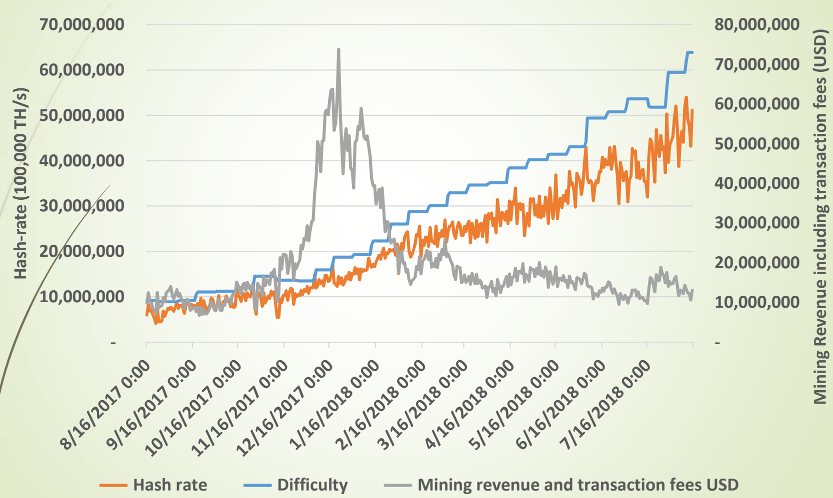
Relationship of Hash-rate, Degree of Difficulty, Hash-rate and Mining Revenue



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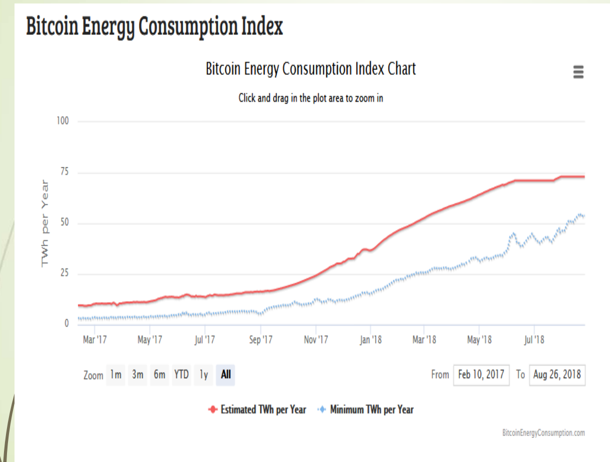
Some Estimates Put Electricity Consumption for Bitcoin mining at millions of Megawatt hours



But

- These estimates are based on market value of Bitcoins.
- Energy consumption is estimated by reverse engineering Bitcoin market value.
- Not based on actual measurements.

https://digiconomist.net/bitcoin-energy-consumption

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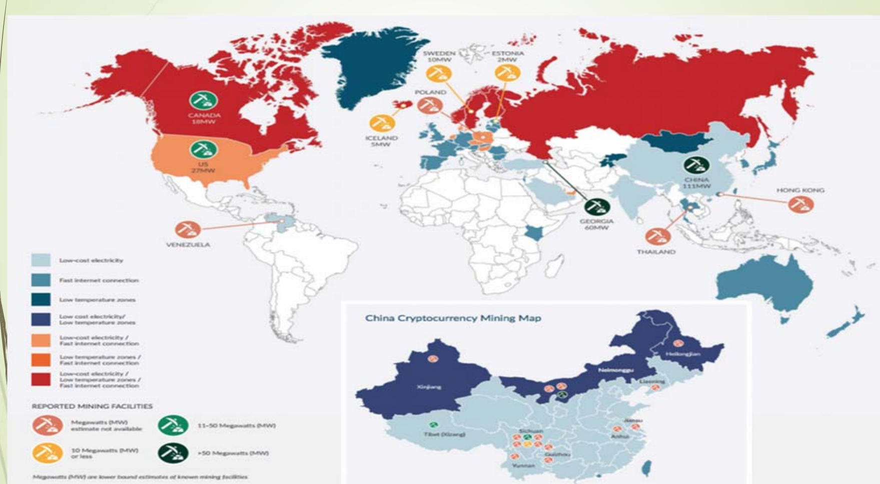
As of 2016-2017 known mining operations worldwide demand around 500 MW



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Why Northwest a Destination for Cryptocurrency mining operations

- Almost same reasons that brought Google and Facebook to the NW.
- Reliable communication infrastructure
- Reliable, Ample, Cheap, Clean power
- Within Northwest the miners are going to utilities in the intersection of cheap, reliable power with good communication infrastructure, low latency.

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Role of Communication investments to create a fertile ground for Data Centers

Mr. Christopher Tamarin, Telecommunication strategist Oregon Business Development Department will now present on past, current and future investment strategies that has helped bring large data centers to the region.

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How big is the Mining loads in the NW

Council's survey of utilities shows that:

1) **Depending on scale of mining, local utility may not even know that there is a mining operation in their service area.**
2) **Our survey shows that in 2017 "known" mining loads was about 38 aMW**
3) **There has been a rush of new connect request in 2018, however many of these connection requests are not going through.**

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What utilities are doing about Bitcoin miners in their service area?

- **Utilities are taking a cautious approach.**
- **Taking into account regulatory risk, business risk and load risk of this market segment.**
- **Some are discovering they have mining operations in their service area.**
- **Most are slowing down acceptance, putting moratorium on new connection request.**
- **Most are tailoring special term contracts putting economic risk on the miners and protecting ratepayers.**

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Are there energy efficiency measures applicable to Bitcoin miners?

- Currently, there are no appliance/computer standards applicable to the mining equipment
- Most efficiency measures on computers are targeting the idle state of computers. Not much idle time in mining op.
- HVAC improvements are possible
- There are some new chip technologies are expected from Intel that reports to lower the energy consumption by 30%.
- The best way to reduce energy consumption in bitcoin mining is to change proof-of-work requirement.
- Mechanism for adjusting Degree of Difficulty in the blockchain, which increase computational requirement to get a coin, works against efficiency in electrical consumption of mining operations.

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Regional Opportunity-Cost of Mining

- We estimated the current known electrical demand for Bitcoin mining is at least 38 aMW.
- We had estimated that, in 2015 regional manufacturing sector produced $37 million dollars of value-added for every 1 aMW of electricity it used.
- The direct opportunity-cost of mining in the region is $1.4 billion dollars.
- Including multiplier/indirect raises the opportunity-cost to $2 to $3 billion dollar.
- This level of economic output should create 18,000-27,000 New Jobs in the region.
- Bitcoin miners do not provide economic growth comparable to other industrial activities.

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Summary

- Creation of cryptocurrency aimed at creating a trust-less mechanism for peer-to-peer electronic cash system.
- Bitcoin is not Blockchain.
- The current verification methodology for Bitcoin extremely electricity intensive and most likely sustainable.
- As number of coins increase, so would Degree of Difficulty and electrical load per coin.
- There are limited efficiency measures available.
- Opportunity cost of mining is far greater than benefits.
- Meeting electrical demand for this class of customers require a careful risk assessment.

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Future Presentation Planned

- Currently we are planning for a presentation on different applications of Blockchain technology.
- Electric utilities, Distributed Generation
- Healthcare
- Supply management
- Financial
- Scheduled for November.

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Oregon Broadband

Christopher Tamarin
Oregon Business Development Department

September 11, 2018

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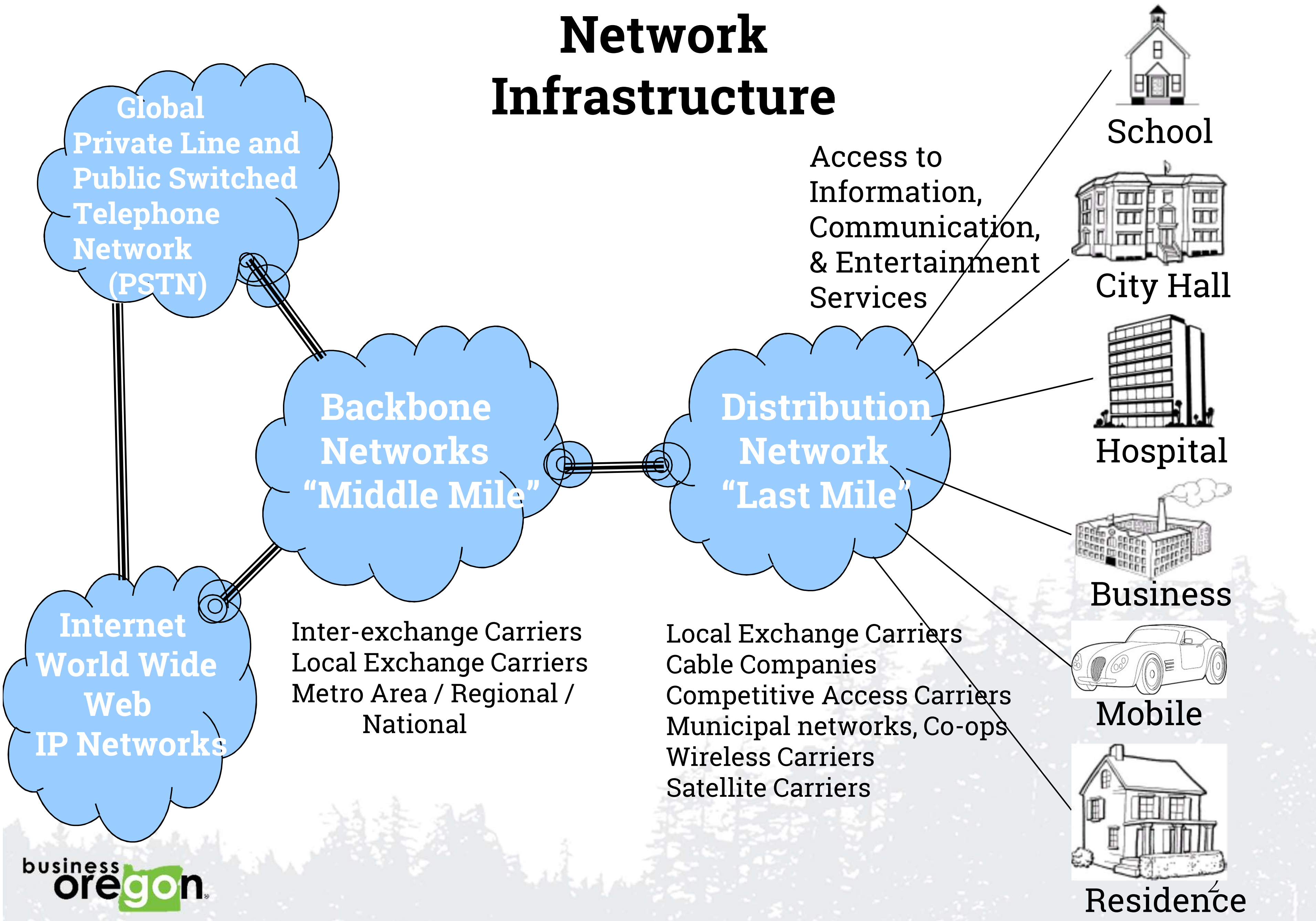
Telecommunications Network Infrastructure



Broadband as Essential Service

"Like electricity a century ago, broadband is a foundation for economic growth, job creation, global competitiveness and a better way of life. It is enabling entire new industries and unlocking vast new possibilities for existing ones. It is changing how we educate children, deliver healthcare, manage energy, ensure public safety, engage government, and access, organize and disseminate knowledge."

-The National Broadband Plan

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Broadband as Meta-Infrastructure

Broadband telecommunications may be viewed as a meta-infrastructure, an infrastructure that adds to and enhances other infrastructure.

- Power grids
- Transportation systems
- Water and wastewater systems
- The emerging Internet of Things

Oregon Public Policy

- "…it is the goal of this state to promote access to broadband services for all Oregonians in order to improve the economy in Oregon, improve the quality of life in Oregon communities and reduce the economic gap between Oregon communities that have access to broadband digital applications and services and those that do not…" [ORS 759.016(1)]

- "It is the policy of the State of Oregon to promote, facilitate and encourage activities, projects and businesses that improve Oregon's Internet Protocol network infrastructure, performance and connectivity to the Internet backbone network and World Wide Web for the benefit of Oregon's commercial, educational, governmental and individual users." (SJR 19 (2007))

Broadband Service Providers

- Franchised telephone companies
- Franchised cable companies
- Mobile wireless cellular companies
- Satellite companies
- Competitive Access Providers
- Municipalities/public entities/ public-private partnerships / Co-ops

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Key Broadband Technologies

- **DSL** (twisted pair copper / legacy PSTN)
- **Cable-Modem** (coaxial cable)
- **Mobile Wireless** (3G / 4G / 5G)
- **Fixed Wireless**
- **Satellite**
- **Fiber-to-the-Premises**

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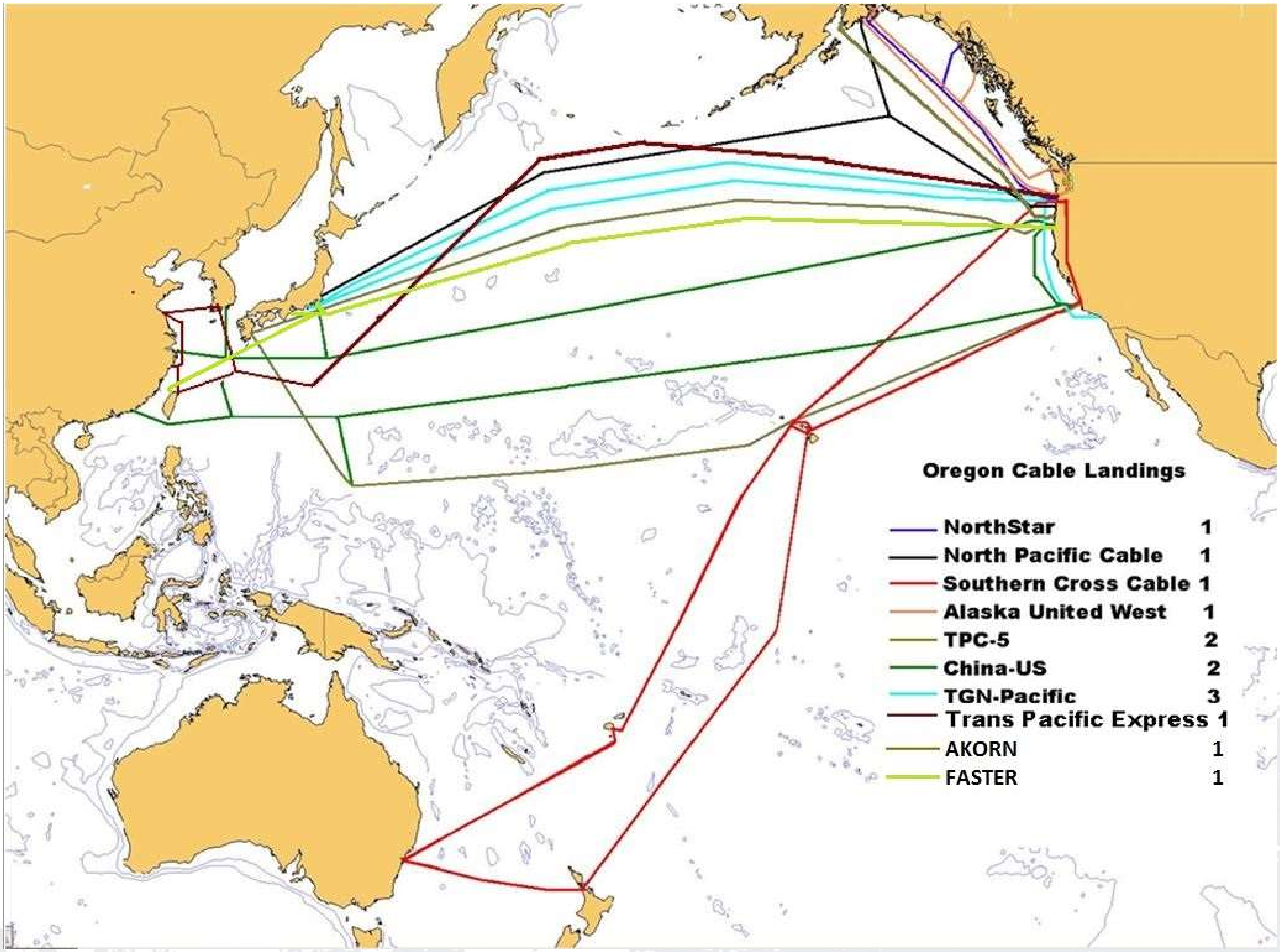

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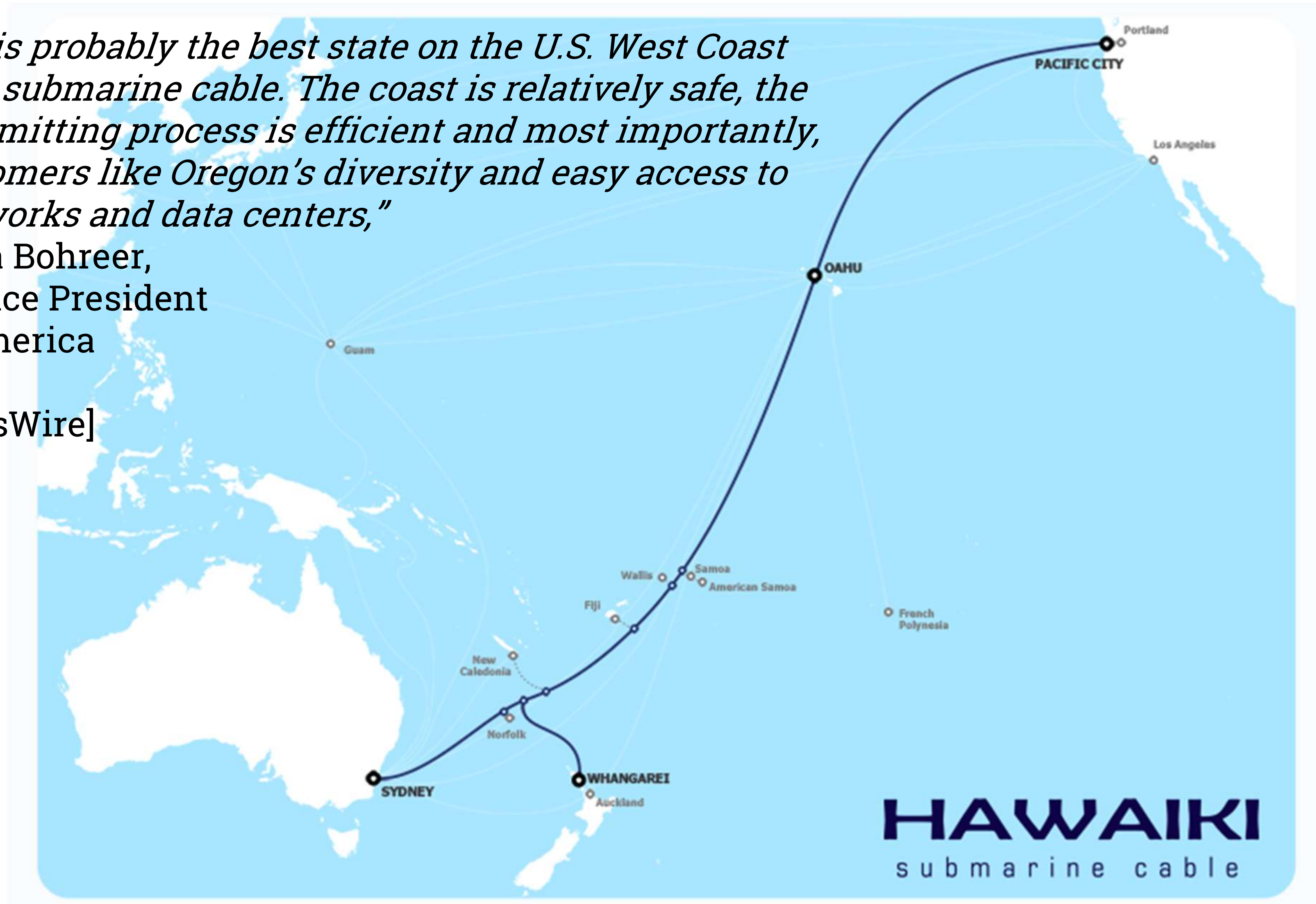
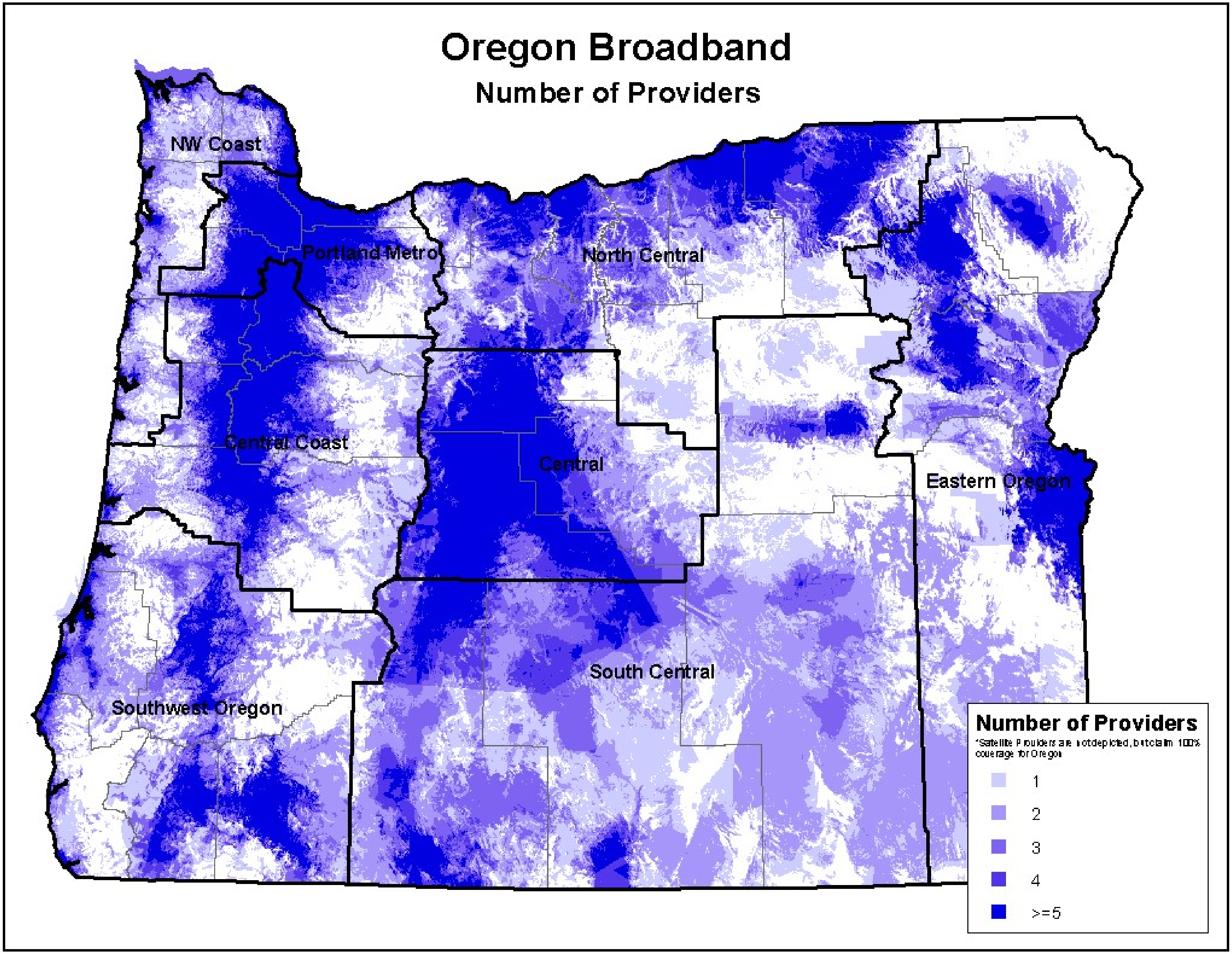
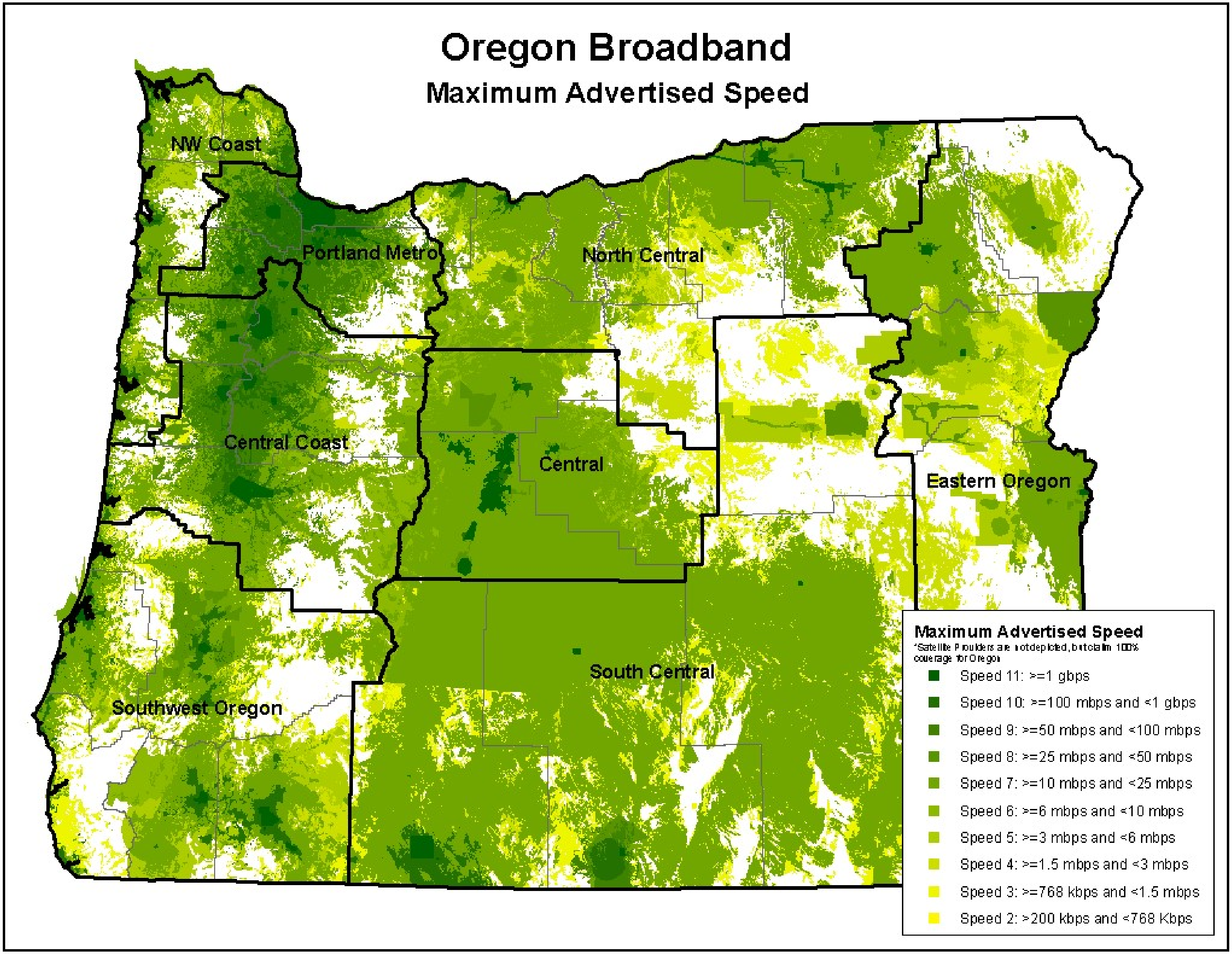
Hawaiki – In Service July 2018

"Oregon is probably the best state on the U.S. West Coast to land a submarine cable. The coast is relatively safe, the state permitting process is efficient and most importantly, our customers like Oregon's diversity and easy access to U.S. networks and data centers,"
said Gina Bohreer,
Senior Vice President
North America
Hawaiki.
[BusinessWire]




Oregon Broadband
Number of Providers
NW Coast
Portland Metro
North Central
Central Coast
Central
Eastern Oregon
South Central
Southwest Oregon
Number of Providers
1
2
3
4
>=5


Oregon Broadband
Maximum Advertised Speed
NW Coast
Portland Metro
North Central
Central Coast
Central
Eastern Oregon
South Central
Southwest Oregon
Maximum Advertised Speed
*Satellite Providers are not depicted, but claim 100% coverage for Oregon
Speed 11: >=1 gbps
Speed 10: >=100 mbps and <1 gbps
Speed 9: >=50 mbps and <100 mbps
Speed 8: >=25 mbps and <50 mbps
Speed 7: >=10 mbps and <25 mbps
Speed 6: >=6 mbps and <10 mbps
Speed 5: >=3 mbps and <6 mbps
Speed 4: >=1.5 mbps and <3 mbps
Speed 3: >=768 kbps and <1.5 mbps
Speed 2: >200 kbps and <768 Kbps

Continuing Digital Divide

Broadband Status	Total	NW Coast	Portland	Central Coast	SW Oregon	North Central	Central Oregon	South Central	Eastern
Broadband at home	82%	78%	85%	83%	79%	76%	83%	69%	67%
Not-at-home Internet User	4%	6%	4%	2%	4%	3%	5%	6%	4%
Dial-up	1%	3%	1%	1%	2%	1%	2%	1%	4%
Internet Non-user	13%	14%	10%	13%	15%	20%	10%	24%	25%

Oregon Broadband Adoption by Region

Technology Trends

Rapid advances in technology, network performance, capacity and capabilities

Market migration from voice to text and data

Market migration from landline phone service to wireless and broadband

Network migration to Internet Protocol (IP)

Growth of end-user device mobility – wireless to the device

Emergence of Cloud Computing and Everything as a Service residing in the Cloud

Emergence of the Internet of Things

Networks are becoming more robust and self-healing

Emergence of broadband as the end user's primary delivery network connection for all applications

Applications

- Communication
- E-Commerce
- E-Government
- Education
- Energy management
- Public safety / security
- Healthcare
- Entertainment
- Internet of Things

A Challenging Work in Progress

- Broadband infrastructure will always be a work in progress as technologies and applications change over time.
- What constitutes broadband, e.g., transmission speeds of thousands of bits per second, millions of bits per second, or billions of bits per second will be a moving target.
- The Internet has emerged as the global platform for communication, business, government, education, information storage and distribution, and entertainment.
- Competitive high-speed access to the Internet and telecommunications networks is essential for Oregon's institutions including schools, businesses, government, health care and individual citizens.

Oregon Broadband Advisory Council

- Encourage coordination and collaboration between organizations and economic sectors
- Leverage the development and utilization of broadband for education, workforce development and telehealth
- Promote broadband utilization by citizens and communities.

www.broadband-oregon.org

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OBAC Recommendations

Oregon's broadband public policy needs to be focused on the future, more aggressive, more financially supportive, more specific, and have a sense of urgency.

- **Create an Oregon Broadband Office**
- **Provide State Funding**
- **Reduce barriers to broadband infrastructure deployment**
- **Reduce barriers to adoption**
- **Remain technology neutral**

Oregon Connections
Telecommunications Conference
October 18-19, 2018

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Oregon Connections: Digital Inclusion

October 18 and 19, 2018 - Hood River, Oregon

www.oregonconnections.info

2018 Conference

The Oregon Connections Telecommunications Conference draws attendees from all regions of the country to share ideas, experiences and knowledge about telecommunications.

The 2018 conference presenters and attendees will explore **Digital Inclusion**, the challenge of ensuring that all individuals and communities have access to affordable state of the

When? Oct 18-19, 2018

This year's conference theme is **Oregon Connections: Digital Inclusion**. See program details.

Our Keynote Speaker is **Mary Beth Henry, Digital Equity/Broadband Consultant**. Learn more.

Join our speakers, panels, group discussions, breakfast - luncheon - refreshments, receptions and more.

Held at Hood River, OR

The 23rd annual Oregon Connections Telecommunications Conference will be held on Thursday and Friday, Oct 18-19, 2018 at the Best Western Hood River Inn, Hood River, OR.

Ask for special conference rates.

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