Gigabit Wireless

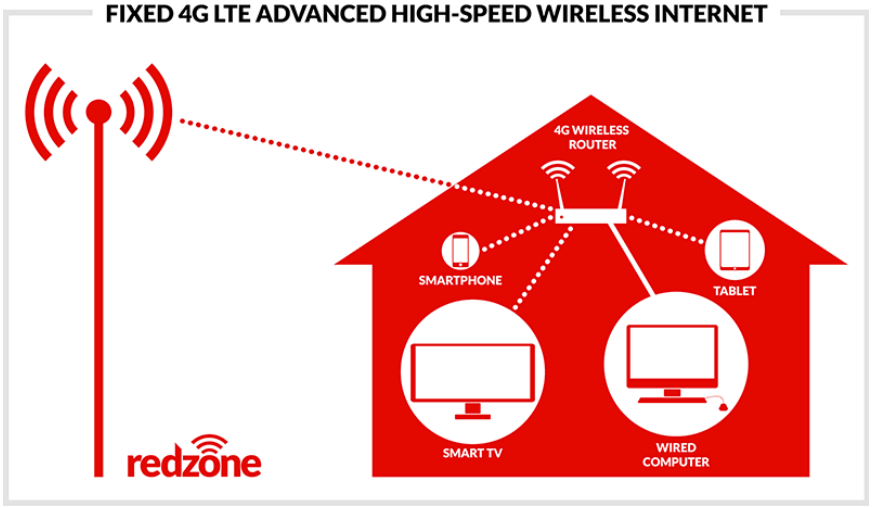
5G Connectivity for the Columbia River & Coast

Oregon "wireless fiber" research by Sam Churchill

1. Overview of broadband wireless coverage in Oregon

Oregon Broadband in 2016 is concentrated in urban areas. Cellular broadband along the Columbia River is poor below Longview, where Interstate 5 and the Columbia River diverge. This paper overviews an approach to use 5G wireless technology to make wireless broadband more affordable and practical everywhere, but especially along the Columbia River and down the Oregon coast.

Redzone Wireless, a Wireless Internet Service Provider (WISP) in Maine, uses 4G 2.5 GHz spectrum for the backhaul and Wi-Fi inside the home, for 50 Mbps fixed service, for $80 per month.
They use BreezeCOMPACT 3000 basestations (which also work at 3.5 GHz).



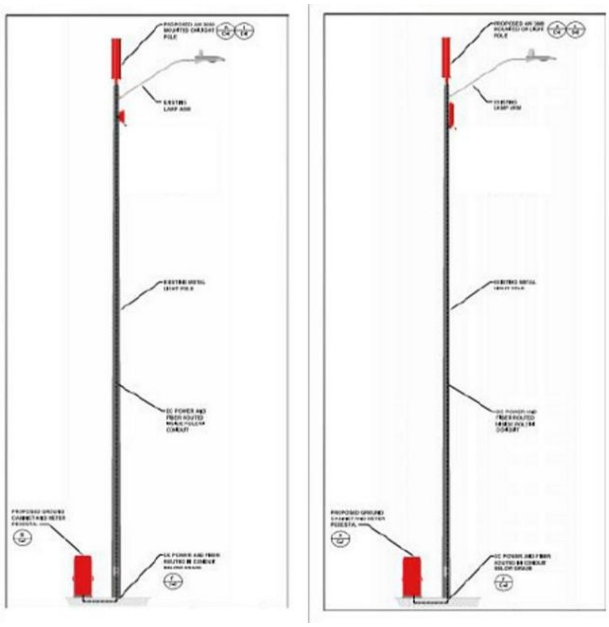
Recent developments indicate that 5G may be utilized to deliver 100 Mbps for $20/month for Oregonians. This "wireless fiber" may be enabled within 2-3 years, using LTE on the shared (unlicensed) 3.5 GHz band with a 3-5 mile range, and much lower CAPEX and operating costs then current FTTH or 4G wireless.

2. The next wireless standard: 5G

The first 5G commercial service launches in Sept 2017, in preparation for the 2018 Winter Olympics in Korea. 5G arrives en-mass with Rel-15 in 2018-19. That is expected to bring 100 Mbps "wireless fiber" to homes and businesses for less cost than any other option. "Wireless Fiber" eliminates FTTH.

The 3.5 GHz band is supported by the Qualcomm's X16 LTE modem, with licensed and unlicensed spectrum aggregation. Beamforming and carrier aggregation, of the type used by Google's Fi network, could help transform the Northwest economy by delivering 1 Gbps wireless — right now.

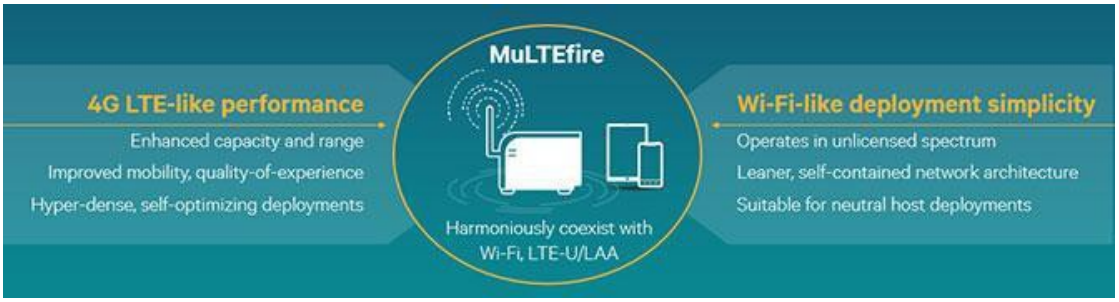
The Snapdragon X50 5G modem will make "wireless fiber" absolutely compelling in 3 years with a 10x speed/cost advantage of 5G. Intel's 5G modem, ready for testing in a few months, supports the 3.3-4.2 GHz band as well as 28 GHz. Google's 3.5 GHz wireless infrastructure on city light poles deliver Gigabit wireless for many blocks in Kansas City today.



Proposed
KCMO street
light designs

Google

MulteFire enables any entity, regardless how small they are, to operate their own LTE network in unlicensed spectrum. It's targeting the 5 GHz and 3.5 GHz bands and allows one radio to serve multiple operators.



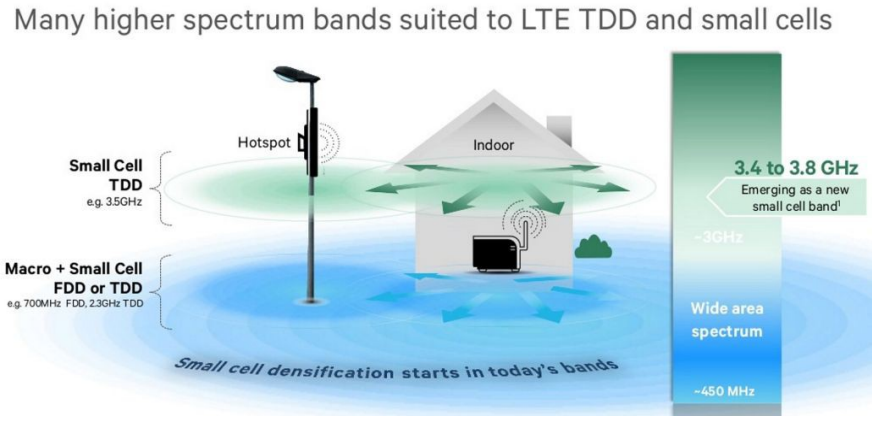
The Multefire unlicensed LTE standard is supported by Qualcomm, Intel, Google, Ericsson, Nokia, Huawei, Comcast, Boingo, Cisco, Ruckus and others. It's "free" spectrum. Shared by many. Like WiFi.

3. Benefits of 5G Wireless at 3.5 GHz

The benefits of shared 3.5 GHz radios, spectrum and infrastructure include:

(a) one radio shared by competitors
(b) "free" spectrum
(c) common backhaul
(d) common management of devices
(e) an open system not tied to a single vendor or network provider
(f) inexpensive "wireless fiber" service

5G LTE using shared 3.5 GHz spectrum is expected to provide a 10x increase in speed and a simultaneous decrease in cost. Providing all residents with 100 Mbps speeds – at much lower cost – will start to happen in the next 2-3 years. Guaranteed.



Ericsson and China Mobile have a 5G drone, providing 1.5 Gbit/s to the drone using the 3.5GHz band. Handoff between towers can extend the 10 mi range of a DJi Inspire to hundreds of miles. 3GPP Release 14, ready in 2017, also defines Cellular-V2X for autonomous cars on 5.9 GHz.

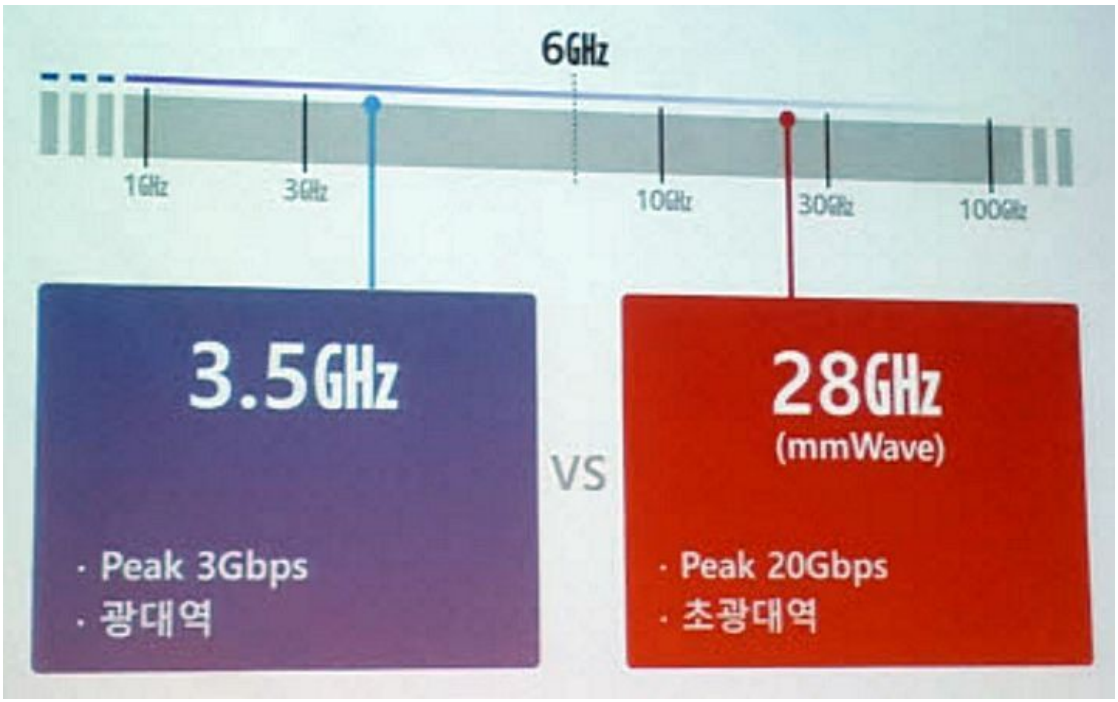
Potential 5G Infrastructure along the Columbia River

AT&T's 3.5 GHz mobile radios operate within a 20 kilometer (12 mile) radius of mobile stations , according to AT&T's FCC application.

Intel 5G Mobile Trial Platform		
Communiation Stack	· Powered by Intel Core i7 processor · Dual connectivity	
Radio Frequency Unit	· Sub-6GHz & 28 GHz mmWave · Four-stream MIMO	
Baseband Processor	· Five Altera 'Arria 10' FPGAs	

A coop infrastructure provider can rent bandwidth to multiple carriers using the 3.5GHz band. Everyone wins. Network slicing allows huge numbers of service providers and enterprises, including small ones, to use a virtualized, on-demand 'slice' of the network. The software as a service operator assigns a spectrum slice dynamically.

SandyNet is a good model, delivering 100 Mbps for $40/month. SandyNet runs their fiber utility on a break-even basis. 5G wireless on 3.5 GHz would be cheaper than fiber to the home (FTTH).



The 5G-SIG specification supported by Intel, Qualcomm, Samsung, Ericsson, Nokia, and Verizon is now available for implementing this September, but it's a draft, more oriented to 28 GHz. The 3.5 GHz shared network delivering 5G at 100 Mbps speeds within a coverage range of 5 miles is expected to be available by 2018/2019. One radio. Many carriers. Shared cost. Like WiFi.

5. Goals of 5G Wireless along the Columbia River

Our primary target is 100 Mbps "wireless fiber" service for $20/month. Let's perform some idle "back of the napkin" calculation to help determine the validity of this wild speculation.

1. **Better coverage**. The range of 2Ghz (AWS) and 2.6 GHz (Band 41) is now essentially the same – about 8 miles to the cell edge, thanks to higher power at 2.6 GHz and 8T8R antennas.
2. **1 Gbps on 4G today**. Using 3 band aggregation today's 4G can deliver 1 Gbps.
3. **15 mile range.** If macrocell coverage averages 7.5 miles in each direction (15 miles total), then perhaps 10 macrocells on 2.5 GHz might cover the entire Portland to Astoria leg.
4. **Fewer towers.** The 120 mile Columbia River corridor might need only a dozen macro towers.
5. **Cheaper, better repeaters.** Another dozen "relay stations", about the size and cost of public WiFi hotspots, might fill in coverage from the Washington side. No need for backhaul. They're solar-powered and located hundreds of ft above the river.
6. **Wireless Fiber.** In dense urban areas, 3.5GHz radios can deliver 1 Gbps broadband to homes and business. Typically it would be 20-100 Mbps, serving 50-100 homes per tower.
7. **Inexpensive.** If a total of 30 radios were required, each costing an average of $30K ($10K for installation/$20K for the radio), that totals under $1 million.
8. **Fiber backbone.** The feds have been subsidizing cellcos for decades. Fiber would be laid from Portland to Astoria, along the Portland and Western Railroad line.

If the entire 120 mile network had a total of 10,000 subs, each paying $20/mo, that's theoretically $200K/mo x 36 months or $7.2 Million by year three. If operating expenses were half that, it would still make millions.

That's 1/10th the cost of one highway bridge ($70 million). A "wireless fiber" route along the Columbia River or down the Oregon Coast would also pay for itself. Besides supplying homes and businesses with 100 Mbps, the daily river cruises up and down the Columbia would happily pay for mobile broadband – if they could get it.

6. Stakeholders

Stakeholders who may benefit and pay for faster broadband would include consumers, city and county governments, first responders, schools, utilities, PUDs, BPA, ODOT, Ports, large industries, vendors like Intel, cruise businesses, railroads, cellular and cable companies.

Everyone gets 100 Mbps broadband. Governments, schools and parks get it free. Matching state or federal funds might be obtained more easily with a public service, non-profit approach.

Are carriers motivated to do a serious cost/analysis? Perhaps not. Sharing spectrum just increases competition, and they've got government handouts to maintain profitability. Fine. If carriers want to be silos of coal-fired broadband, they can. Private industry could step in, managed cooperatively with local jurisdictions or public utility districts.

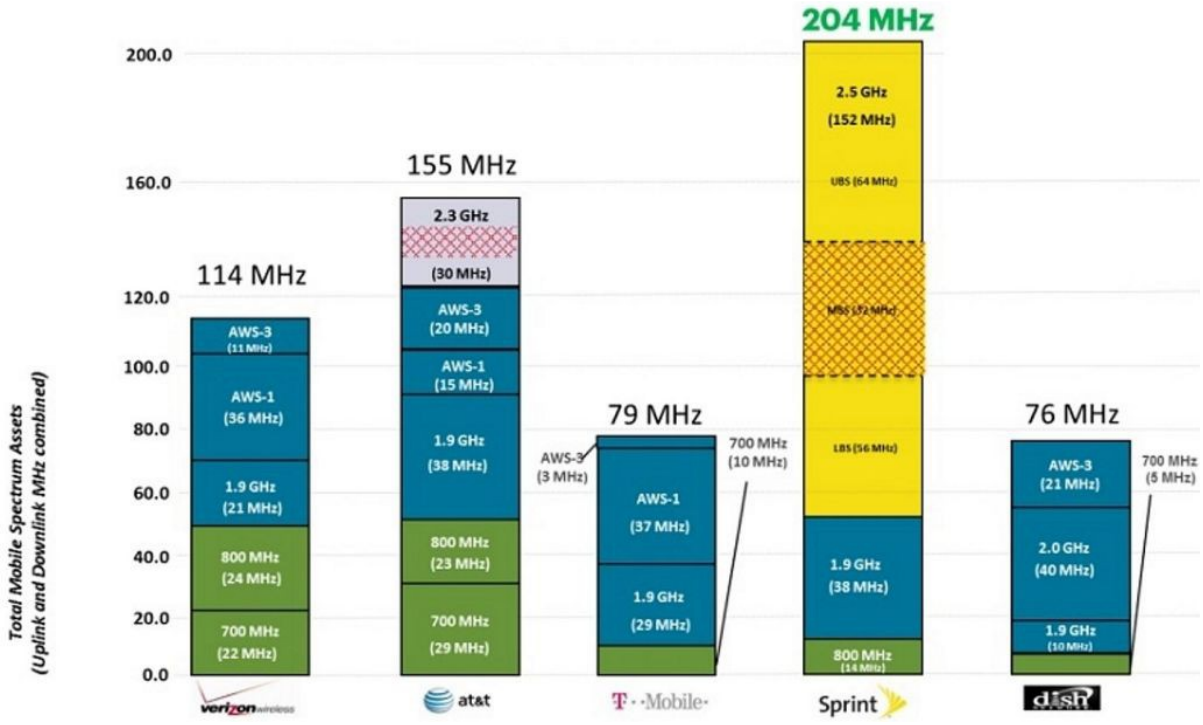
There *is* a profit incentive and a real value proposition. A rack in a data center provides cheaper cloud-based radio control . Expenses are shared.

By contrast, traditional 3G/4G is expensive and slow.

7. Current spectrum and coverage

Sprint coverage in the lower Columbia is currently sub-par. Currently Sprint "Spark" coverage along the Columbia River combines 800MHz, 1.9GHz and 2.6GHz. Using 8T8R antennas, Sprint's 2.6 coverage and 1.9 GHz are said to be similar.

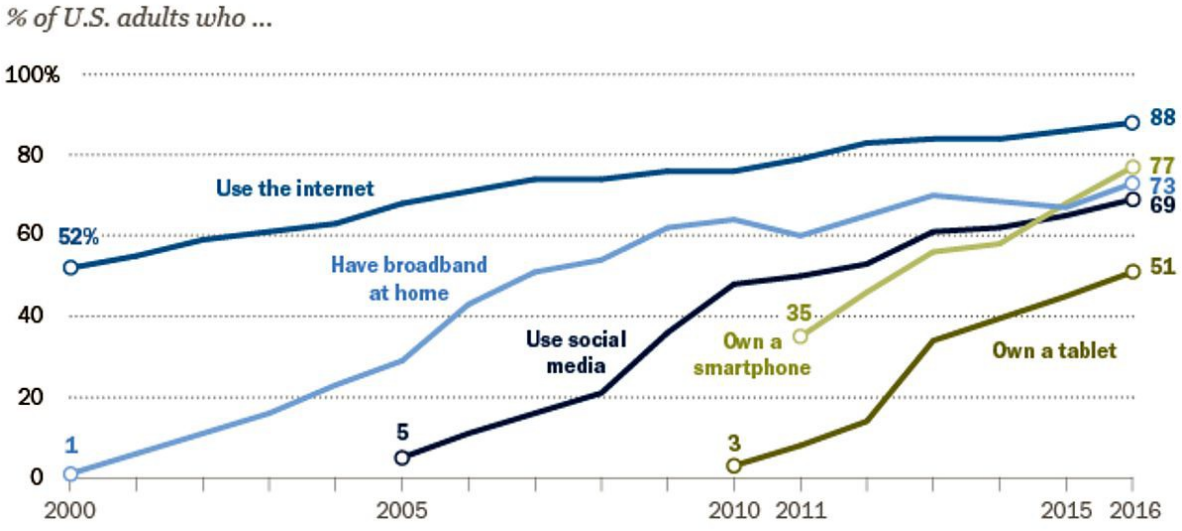
Sprint has more "low band" spectrum available for 5G than any other carrier, nearly 200 Mhz. They could offer 1 Gbp/sec today on their 4G network by simply combining three, 20 MHz channels on 2.5 GHz.



As 5G standards are firmed up, the combination of 2.5 GHz (licensed) and 3.5 GHz (unlicensed) could benefit both Sprint and competing carriers. The cost of the 3.5 GHz radios and the backhaul could be shared by many different competitors. Both the 2.6 and 3.5 GHz bands will use similar technology – Time Division Multiplex LTE – so radios can be simplified and integrated. Costs shared.

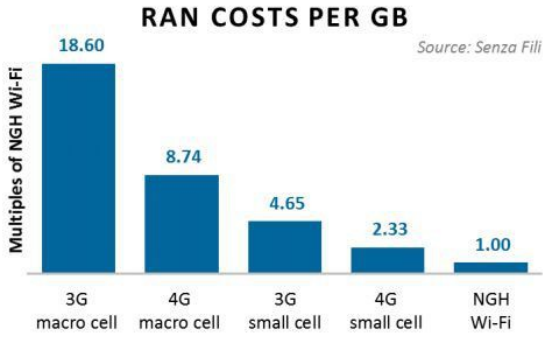
8. Market Projections

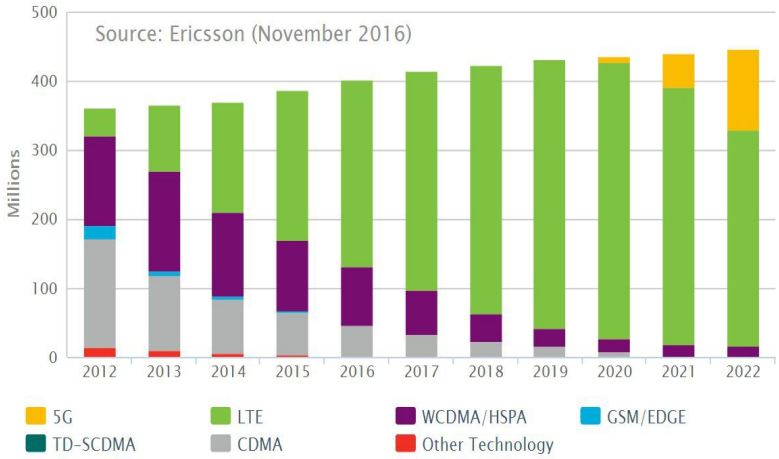
According to Pew Research, nearly nine-in-ten Americans today are online, with nearly three-quarters (73%) of Americans having broadband at home. Some 95% now own a cellphone of some kind and 77% own a smartphone. Nearly seven-in-ten Americans now use social media and half own a tablet computer.



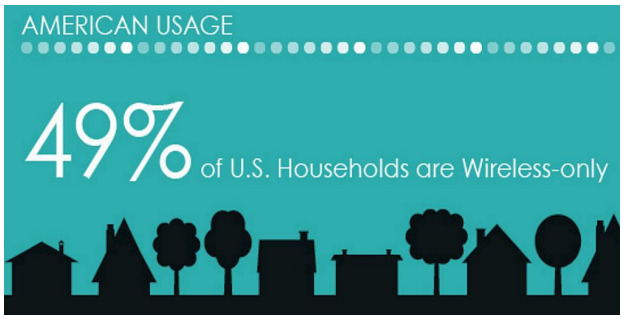
Source: Surveys conducted 2000–2016. Internet use figures based on pooled analysis of all surveys conducted during each calendar year.

PEW RESEARCH CENTER





The CTIA reports 49% of American homes are wireless only. Approximately 12% of Americans are "smartphone dependent" for online access.

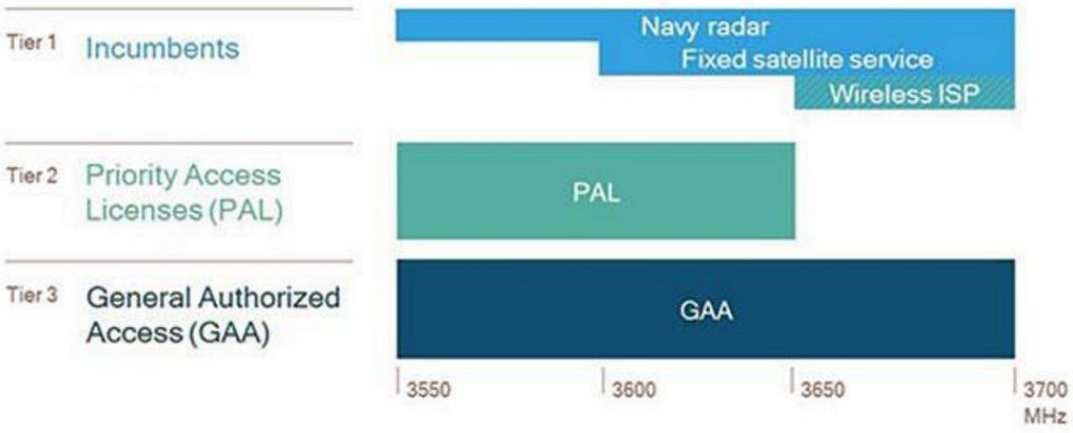


The Ericsson Mobility Report says cellular subscriptions broke 400 million in North America in 2016 and forecasts 550 million 5G subscriptions (world-wide) in 2022.

Fixed wireless broadband is expected to soar with 5G since it is cheaper than fiber and can be competitive with 1Gbps cable service. About 35% of Millennials have never subscribed to cable with "cord nevers" accounting for 9% of the population, **notes Pew**.

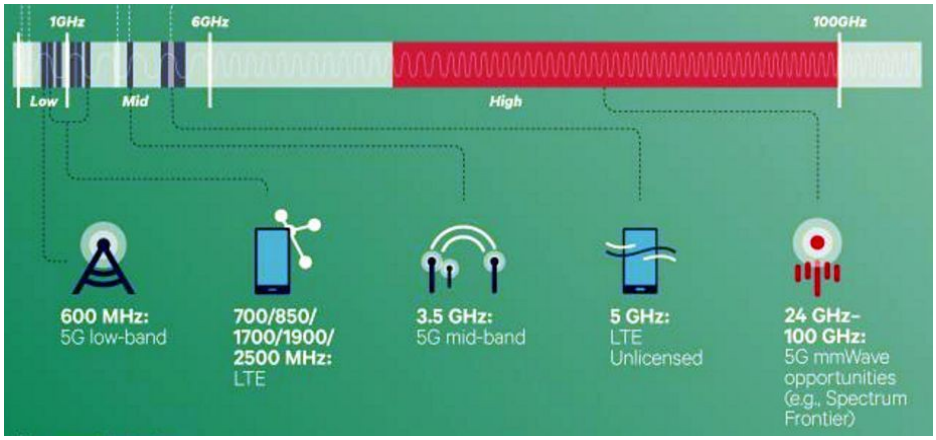
9. Shared Spectrum at 3.5 GHz

If (licensed) 2.5 GHz were shared with (unlicensed) 5.8 GHz and 3.5 GHz, costs could be dramatically lower since multiple providers share infrastructure costs. The innovative **Citizens Broadband Radio Service** in the 3550-3700 MHz (3.5 GHz) range, is available in Incumbent Access tier, Priority Access tier, and General Authorized Access tiers.



Using the either licensed cellular or shared 3.5 GHz shared spectrum, coverage gaps may be effectively closed. The 3.5 GHz band could use LTE-U (carrier-controlled) or Multefire (independent of cellular operators).

Google is a leader in 3.5 GHz shared spectrum while Federated Wireless has the Software As a Service backend. Much like wireless resources are shared in stadiums, a non-profit operating company could manage the spectrum for a variety of wireless carriers up and down the Columbia River, delivering up to 1 Gbps to end users.



The Citizens Broadband Radio Service using 3.5 GHz, can be enabled by Federated Wireless , with the real-time backend, and the CBRS Alliance which develops, markets and promotes LTE-based solutions. Shared spectrum could also be applied to 2.5 GHz licensed bands.

The Wireless Innovation Forum has a signaling protocol for 3.5 GHz that enables different cloud systems to interoperate. Federated Wireless, Google, Sony and others have been approved as administrators.

10. Relay Nodes

Relay nodes are small cells that don't require backhaul. They just repeat the cellular signal. More correctly, they are "translators" since these relay stations use the same frequency but "repeat" the signal on a different time slice. While bandwidth is reduced by half, range is nearly doubled.

Massive MIMO is currently running on 2.6 GHz. Huawei's 128 element Massive MIMO increases range and capacity. Macrocell coverage in the lower Columbia would be supplemented with inexpensive "relay stations", much like radio or tv repeaters. Using 2.5/3.5 GHz (TDD), coverage gaps could be filled.

Solar-powered Relay Stations would be located high on the Washington side of the river. One radio. No Fiber. No Vsat. Put a camera on it. Done.

11. Smart City WiFi Kiosks

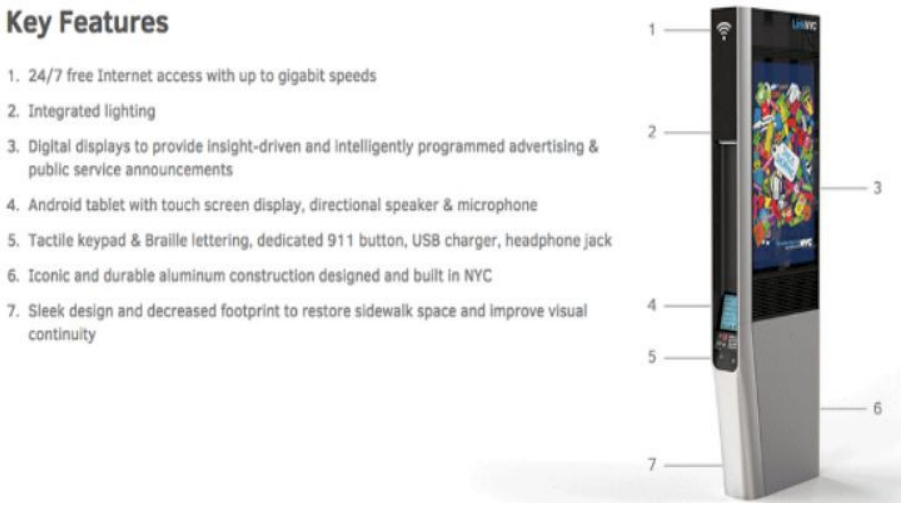
Kansas City and Sprint are creating a "Smart City" along their downtown streetcar line. The city, Sprint and Cisco are putting in 25 interactive digital kiosks at no charge to the city to provide free Wi-Fi along the route as well as installing smart lighting, cameras and sensors. It is expected to be self-sustaining through advertising.

Every community along the Columbia might follow this lead, with interactive kiosks and free Wifi using cloud controlled Open Mesh.

They display community events and generate revenue through ads

These kiosks also double as hubs, distributing 100 Mbps at 3.5 or 5 GHz to end users.

Fiber to the home not required.



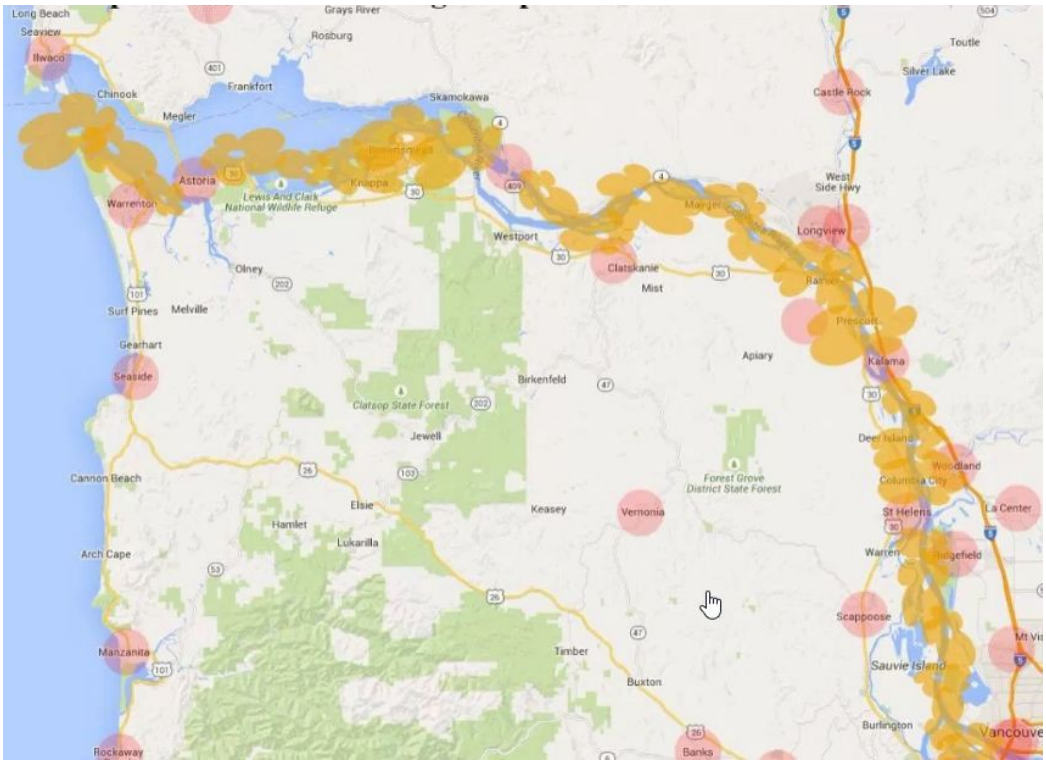
12. Spectrum Summary

If you want 100+ Mbps to the home, only the 2.5 GHz (licensed) and 3.5 GHz (unlicensed) bands have the combination of 100+ MHz of bandwidth (necessary for speed) and the lower frequency (necessary for 5+ mile coverage).

13. The Plan

Delivering 100Mbps broadband to homes and businesses for $20/month is our goal. Fiber to the home becomes (mostly) unnecessary. 5G will support 1Gbps cell-edge data rate.

Instead of expensive macro-cells and associated gear, Alcatel-Lucent's Cloud-RAN puts cellular basestations in a centralized data center. Centralized Intel processors do all the work eliminating bulky cellular gear on the tower. A string of 20-40, 5G towers along the Columbia River, using 2.6/3.5 GHz, would allow "wireless fiber" to the home and could be supported by competing carriers, sharing infrastructure.

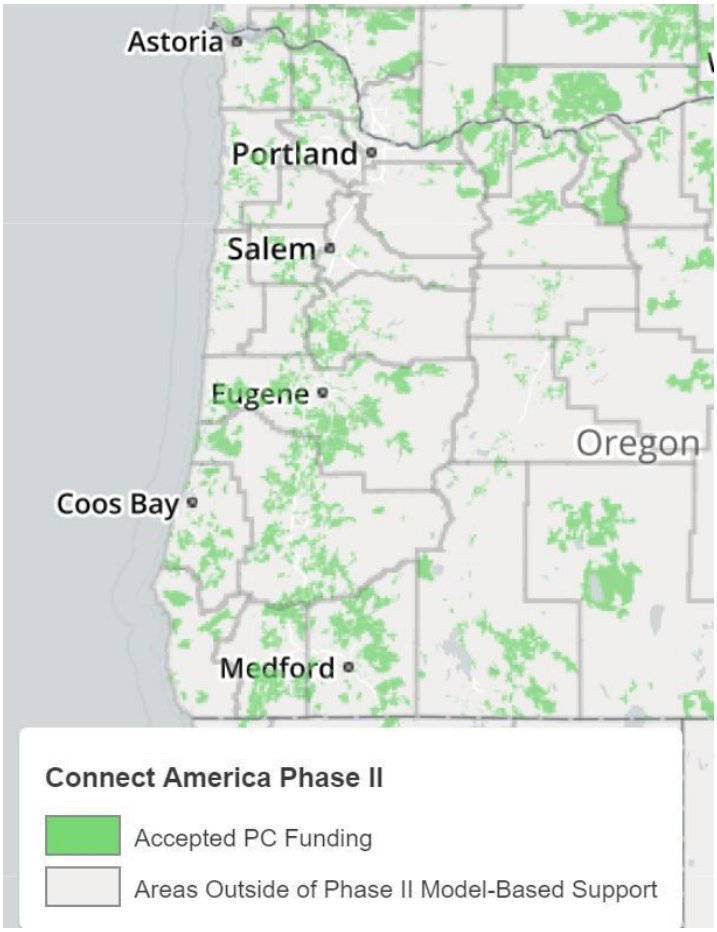


In exchange for free broadband, municipally owned water towers and other infrastructure could be used — far cheaper than tower leases from the duopoly of American Tower and Crown Castle (both own 40,000 towers).

Broadband wireless stimulates economic development. Next gen radios will kick-start drones, autonomous cars and autonomous vessels. It's a perfect storm for 5G using a variety of frequencies. The whole region will benefit.

14. Federal Broadband Funding

The Trump Administration is said to be considering spending $1.5 Trillion in broadband infrastructure. Whatever. Taxes on urban phone bills generate billions of dollars for the Universal Service Fund that serves rural areas. High-Cost Support, now known as the Connect America Fund, subsidizes phone companies that serve mostly rural communities to create rates comparable to urban customers.



The goal of the FCC's Connect America Fund is to have broadband available in nearly 100% of the country by the end of 2020. About $9 billion will be invested over the next six years to approximately 23 million Americans who lack access to 10 Mbps fixed broadband.

AT&T will accept nearly $3 billion in Phase II Connect America Funds, at a rate of $428 million per year over the next four years. Oregon and Washington are NOT among the 18 states where AT&T will use the money. Verizon is accepting $48.5 million in FCC CAF Phase II funding , but this money will effectively be set aside for Frontier, who recently acquired all of Verizon's fixed-line assets. Most of Frontier's government subsidy will go to Eastern Oregon.

In the areas that remain unserved and did not get a government handout, the FCC will award funding through a competitive bidding process. And 3.5 GHz is the way to win.

But the simple reality is that the 10x speed and 10x cost reduction enabled by 3.5 GHz now could make carrier subsidies irrelevant. It's nice to have but now largely unnecessary. Spectrum sharing and 5G are boss.

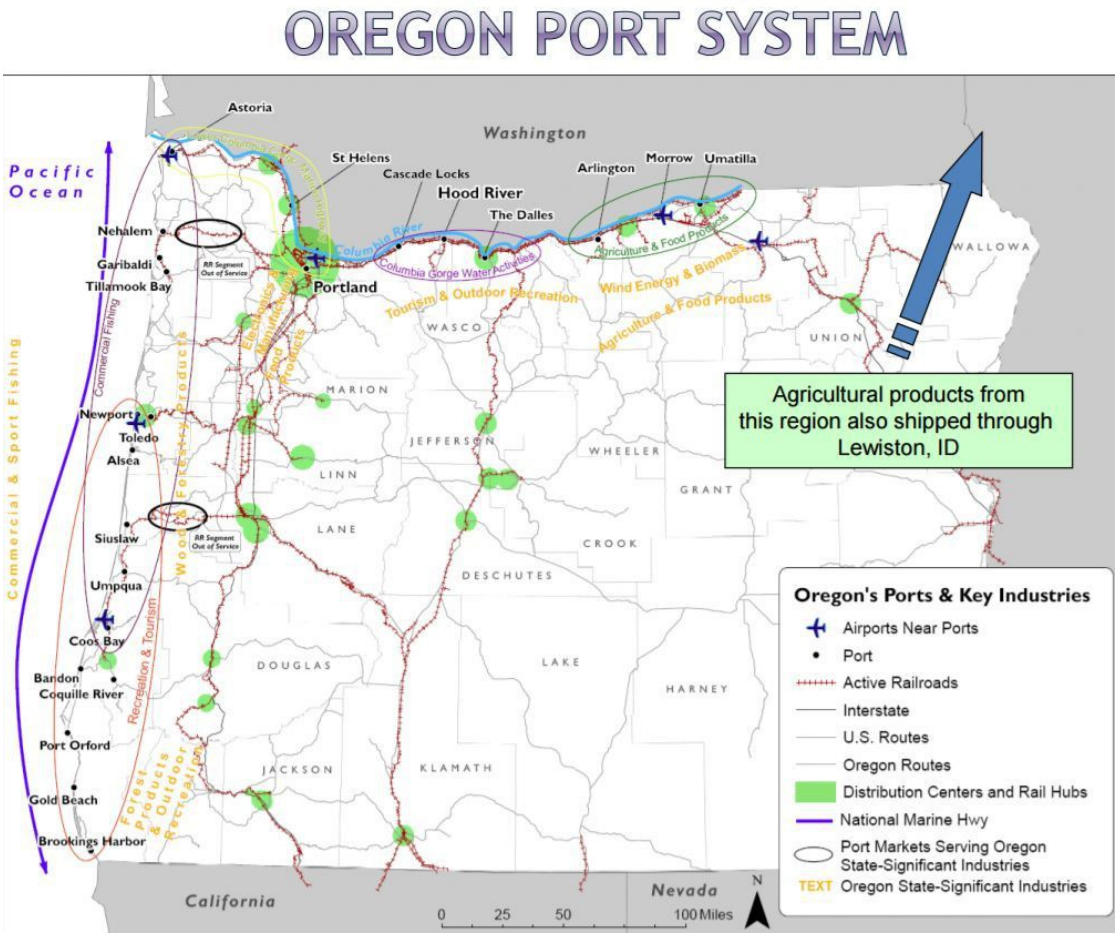
Former FCC Chairman Tom Wheeler believes wireless carriers should partner with each other to move more effectively and efficiently to deploy 5G services.

He's talking about 3.5 GHz. The NO COST shared band has some 150 MHz of bandwidth. Room for all. Shared by all. Like WiFi. Simple. Cheap.

A fiber backbone along the Portland and Western Railroad line might be ideal. All four carriers (and First Responders) could benefit. Everyone wins.

15. Wireless Fiber on the Oregon Coast

The same technology could be applied up and down the Oregon coast. Currently Oregon has NO resilient internet plan after the big quake. But 5G towers, at 3.5 GHz, can deliver 100 Mbps along the coast and Columbia River, starting in 2019. ConnectOregon was created in 2005 as a means to invest in non-highway transportation and economic development.



ConnectOregon has spent hundreds of millions in air, rail, marine, transit, and bicycle/pedestrian infrastructure. For example, Connect Oregon gave the Port of Portland $2.6 million for an Auto Staging Facility at Terminal 6. "Wireless fiber" seems like a good bet for the "information highway", producing revenue and saving money.

There are more than 200,000 people living on the Oregon coast. After a subduction zone earthquake, communications and economies will be virtually wiped out. We have the technology. Let's devise a cost/effective solution. For everyone.

NOTE: This study should be reviewed by a panel of telecommuncations experts before any recommendations are made.

About the author:
Sam Churchill is an independent telecom researcher and founder of Dailywireless.org. He wrote this paper strictly as a personal project, without the backing or support of any individual or company. A linked resource is at: http://www.hayden-island.com/gigabit/