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Emerging Technology Presentation

Selections from Broadband Opportunity Review Project

August 27, 2020

Project Objectives and Key Activities

The Southern California Association of Governments ("SCAG") is performing a broadband market assessment for the 6 county service area

Project Background

- SCAG is in the process of guiding regional policy and supporting members to enable and maximize the benefits of current and future broadband applications, while also minimizing required public investment and disruption to other initiatives.
- This report intends establish SCAG's effort by providing 1 a baseline perspectives on the state of broadband in the SCAG area, 2 broadband investment opportunities, and 3 deployment strategy deployment.

Key Project Questions

- Where are **broadband demand centers** located, and what drives demand in these areas?
- What **types of wireline broadband are available to homes** across various SCAG members?
- How much **customer choice** of providers is available for wireline home broadband?
- What is the general **quality of cellular wireless service** across carriers and SCAG geography?
- What core internet infrastructure exists and where is it located within SCAG's service area?
- What areas, may be **attractive to telecommunication firms** for deploying various types of infrastructure?
- How attractive are these areas and why?
- What are the **implications of the commercial findings**, and what strategies should be explored to **support broadband initiatives**?
- What **other considerations** should be kept in mind as SCAG and its members plan a path forward?

Sources: SCAG

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Telecommunication Landscape

The telecom space is diverse, with significant subsegment interdependencies required to enable BB networks

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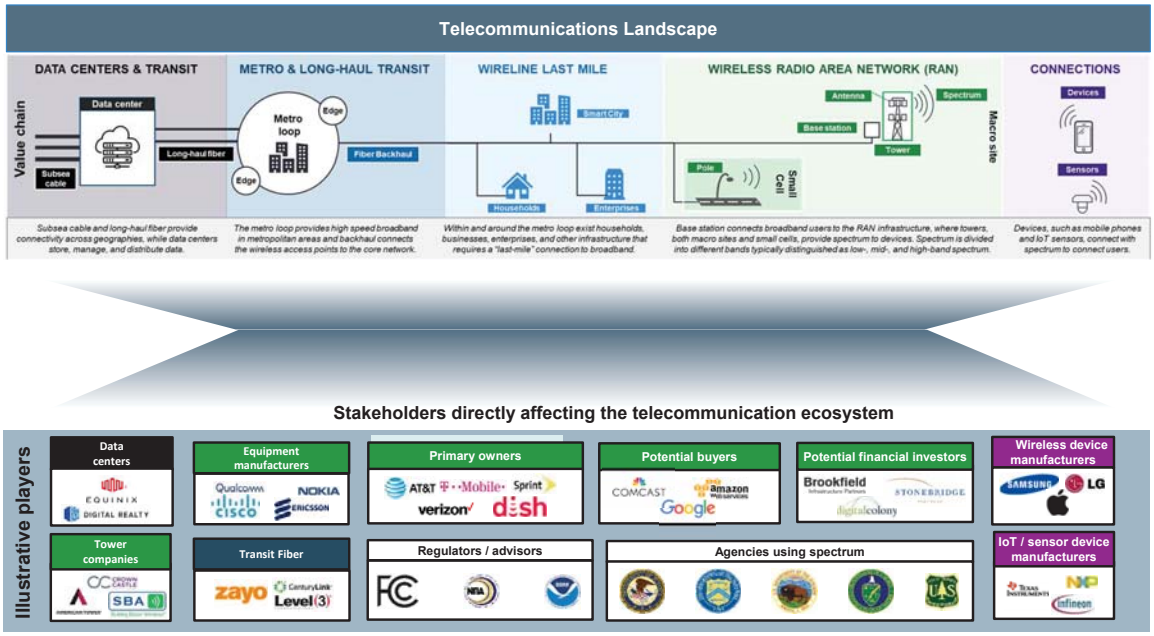

The telecommunications landscape continues to evolve as technology improves, demand evolves, new use cases are developed

Notes: Telecommunications in this context refers primarily to infrastructure
Sources: NTIA, Company websites, SCAG team analysis

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Market Technologies

Fiber is a key enabler of improved service across networks for numerous technology types

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Primary Broadband Technologies[1]

Wireline

Fiber

Broadband through a fiber optic cable

- Provides all layers (sub-sea, long-haul, metro-city, last mile)
- Typically supplied by telecom ISPs
- Advantages: fastest form of broadband
- Disadvantages: best as last mile, but therefore expensive

Cable

Broadband through a coaxial cable

- Historically pieced together for the last mile with fiber layered in
- Advantages: coverage is already extensive with an established customer base
- Disadvantages: technologically inferior to fiber

Copper

Twisted pair, copper wire

- One provided most layers of communication for telephony by telecom operators, but now provided as DSL, VDSL, or others
- Advantages: already exists as a last mile
- Disadvantages: least effective fixed broadband

Wireless

Wi-Fi

Wireless hot spot

- Minimal range, within homes 30-300 meters
- Advantages: Unlicensed spectrum, easy to set up
- Disadvantages: Transfer rate decline with increased users, limited range

Wireless Antenna

Cellular antenna *(small and macro cell)*

- Requires physical upkeep
- Range varies, with Macro cells reaching 5-10 miles
- Advantages: Range, capacity
- Disadvantages: Requires licensed spectrum

Satellite

Geostationary satellite

- Advantages: Range blankets wide regions
- Disadvantages: Interference, data speed
- Note: Recent claims by SpaceX assert high speed satellite broadband is feasible

Coaxial and copper can provide high speed broadband, but must connect to nearby fiber. Copper connections are typically limited in distance from fiber in order to maintain data speeds

Cellular antenna require a connection to the internet backbone, which is ideally through fiber

Notes: Speeds continue to improve on the same physical infrastructure through technological advancements; does not include fixed wireless
Sources: IDC Worldwide Blackbook 3rd Platform Addition, IDC Outlook for 5G' Stepwise Development and Commercialization, Credit Suisse

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Wireline Overview

Broadband networks consist of long-haul, middle-mile, and last-mile, each with varied functions and business models

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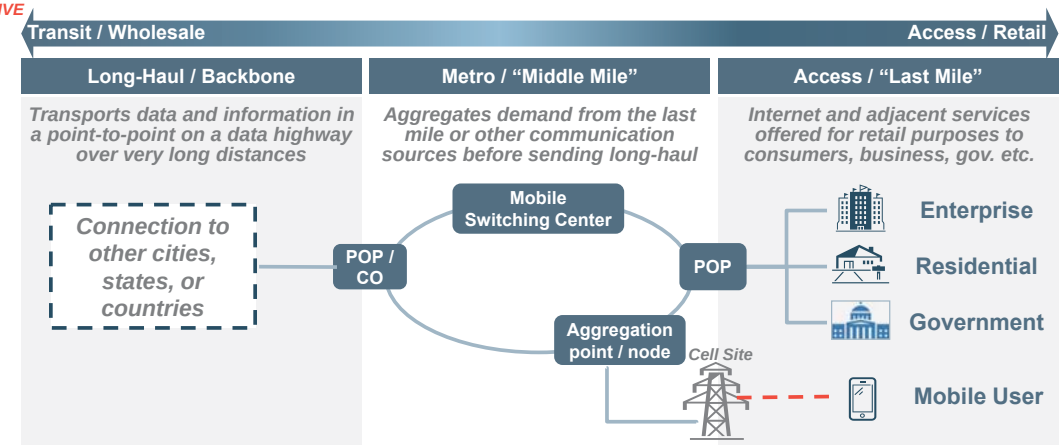

Business Model	Lease fiber strands (per strand, per mile) with maintenance fees. Paid upfront (Indefensible Right of Use "IRU") or expense	Lease fiber strands or a ring (per strand, per mile) with maintenance fees. Paid upfront (Indefensible Right of Use "IRU") or expense.	Sell internet services and adjacent services to individual customers typically on a subscription basis
Providers	Zayo, Level 3	CenturyLink, Windstream, AT&T, Verizon	Verizon "Fios", AT&T "U-verse"
Trans-portation Analogy	Long distance transportation (ocean or rail shipment)	Trucking / tractor trailer freight to larger distribution center or	USPS / courier last-mile service of package or mail to a premise

Note: Point of presence = "POP"
Source: Market Research Fiber to the Home: Capital Costs and Viability of Verizon's FiOS

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Wireline Customer Sets

Wireline customers are highly varied, but all are increasing their demand for fiber

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Customer Type	Demand	Providers
Consumer	Households with a fiber connection (or DSL/Cable that use fiber backbone) now require a high speed data connection	• *Incumbent local exchange carriers ("ILEC") and most competing local exchange carriers ("CLEC") providing fiber to the X ("FTTX")*
Office/Home Office and Small/Medium Sized Enterprises	Companies with up to 250 FTEs with a fiber connection (or DSL/Cable that use fiber backbone) require high speed data to operate	• *ILECs or CLECs providing FTTX*
Corporate Enterprises	Companies with up to 250 FTEs with a fiber connection (or DSL/Cable that use fiber backbone) require high speed data to operate and some have a dedicated fiber line.	• *ILECs or CLECs providing FTTX* • *Providers or resellers of dark fiber*
Government, Public, Other Sites	Local authorities and public institutions (e.g. libraries, schools hospitals) with a fiber connection (or DSL/Cable that use fiber backbone in increasingly required	• *ILECs, CLECs, other middle mile internet service provider ("ISP") with ethernet, dark fiber or other solutions*
Datacenters / Web-hosts	Datacenters providing cloud and hosting services typically use fiber to address their broadband network needs and often leverage a dedicated fiber line.	• *Typically a CLEC, middle mile ISP, or long-haul provider able to offer a dedicated line*
Large Telco Operators	Operators provide B2B/B2C services and offer direct to the customer, resell to the customer, or connect their network. The demand is to handle trunk traffic.	• *Typically a CLEC, with middle mile / long haul off-net offerings*
Wireless and Tower Operators	Mobile operators often use or pay for access to fiber backhaul to transport wireless derived data.	• *ILECs and CLECs transport to the control center through backhaul (often fiber)*

Sources: Pew Research, Vertical Systems Group

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Wireline Availability Drivers

BB availability is typically driven by user density and the average cost to build per household or business passed

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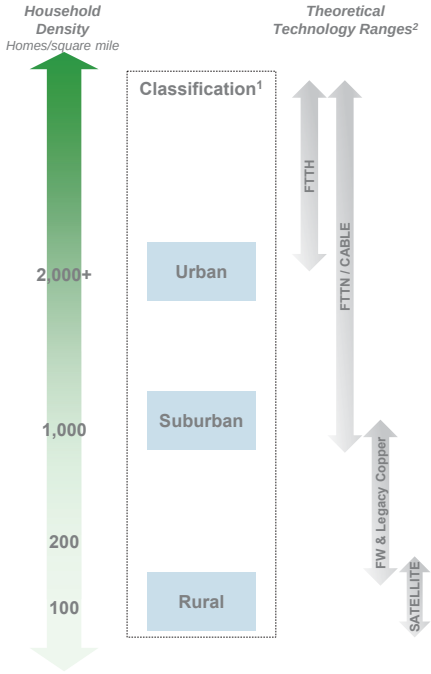
Typical Broadband Offering	Description
Fiber to the Home ("FTTH") *Ideal technology for broadband*	• Providers tend to deploy fiber to the home in the most densely populated areas due to the cost of building the network. End to end fiber can enable market leading bandwidth (Gigabit).
Fiber to the Node ("FTTN") and/or Cable	• Proximity to fiber can support a range of high broadband speeds depending on the network structure. Cable or other technologies provide the end connection to the user. Cable infrastructure over coaxial cable can provide service using a standard named DOCSIS 3, whose more modern versions can support Gigabit (under certain circumstances).
Fixed Wireless & Legacy Copper	• Fixed wireless leverages a wireless transmitter, which communicates with customers' receiver equipment. The technology can provide respectable bandwidth if connected to nearby fiber, but often leverages microwave relays, which impacts performance.
Satellite *Typically considered the lowest quality broadband*	• Wireless communication between user equipment and a satellite usually offer subpar performance below that of typical broadband. Satellite tends to be a last resort, and used in remote areas.



Notes: 1) Official classifications lack formal definitions. FiveThirtyEight survey definition is Rural = >100 households per square mile, Sub-urban = ~100-2000 households per square mile, and Urban = +2,000 households per square mile). 2) Cost/household passed or connected and customer lifetime value would also be considered

Sources: FiveThirtyEight, US Census, US Department of Agriculture, Statista, S&P Market Intelligence

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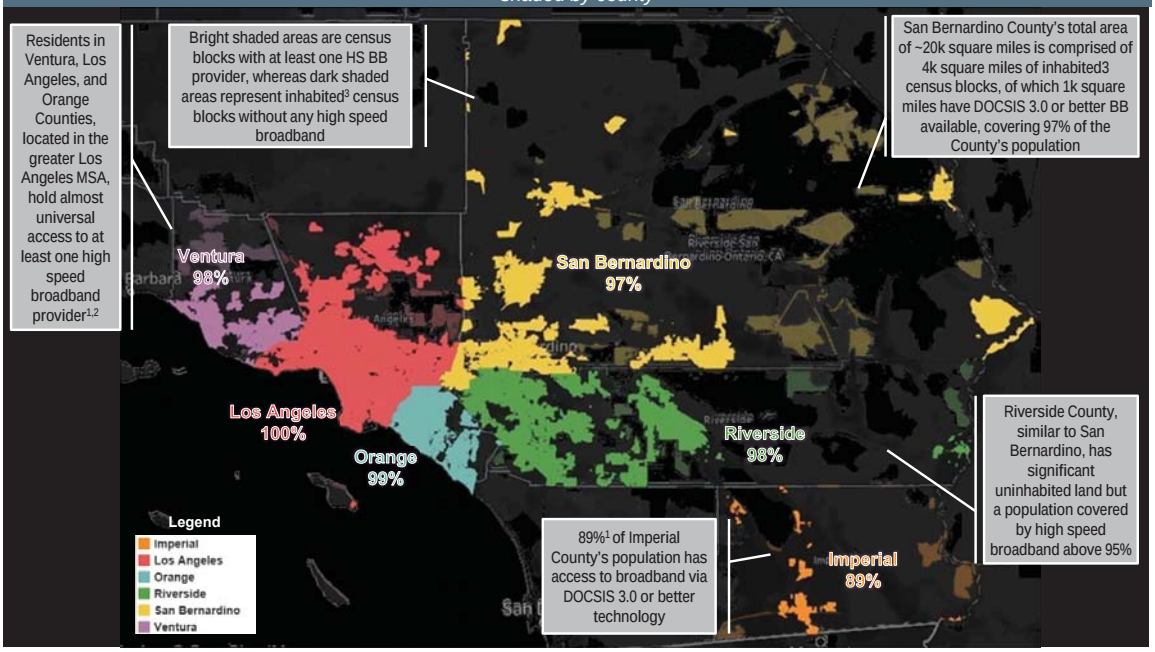
Executive Summary: SCAG Baseline – Last Mile Consumer Broadband

The majority of the SCAG service area population reportedly has availability of at least one high speed broadband provider[1,2] in the last mile access network

Inhabited[3] SCAG service area census blocks with high speed BB availability[1], *shaded by county*



Notes: 1) Availability based on company reported data to FCC on offerings by census block 2) High speed BB referenced here based on technology offering and may not always translate to user experience of high speeds 3) Population >=1

Sources: US Census, FCC, Market Research, SCAG, SCAG team analysis

Executive Summary: SCAG Baseline – Last Mile Consumer Broadband

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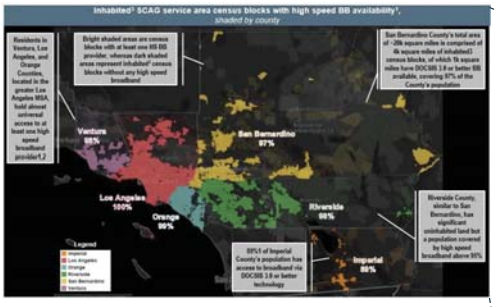
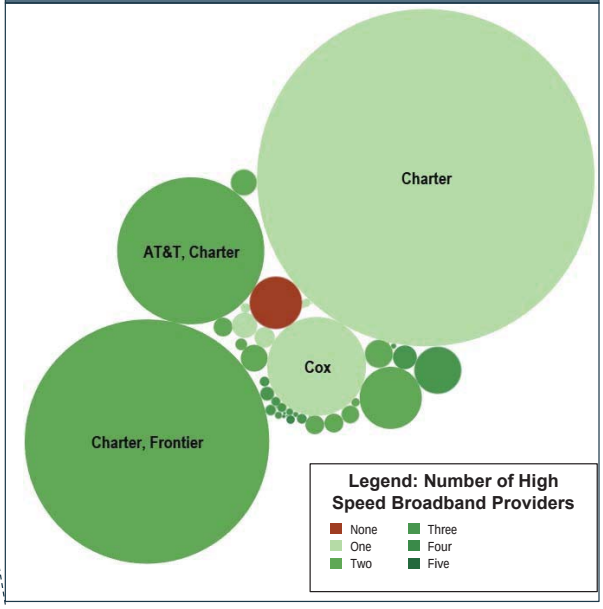
Despite having at least one provider, low competitive intensity suggest that the broadband quality is likely poor



High speed broadband providers[1],
shaded by number of competitors[2] in same census block, sized by population covered



Sources: US Census, FCC, Market Research, SCAG, SCAG team analysis

Supply: Competitive Intensity & Consumer Choice

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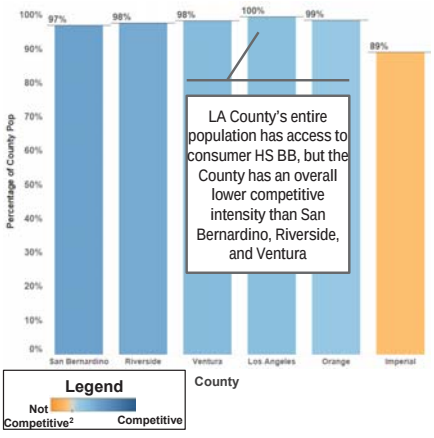
Competitive intensity, evaluated primarily by breadth of customer choice, enables further differentiation

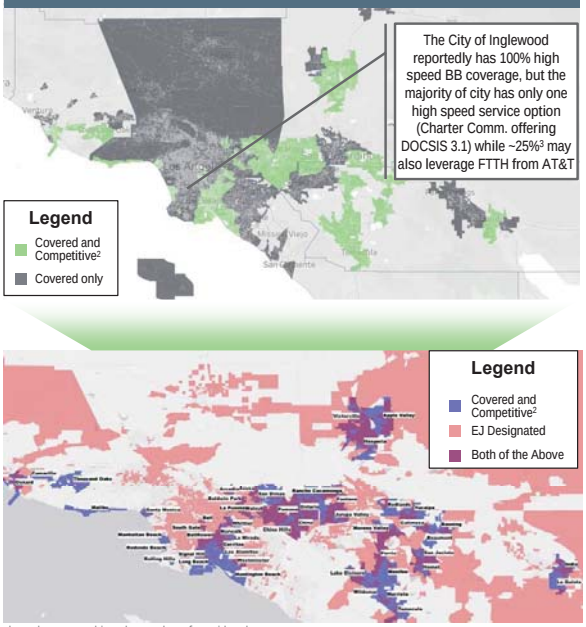
County level population percentage covered[1] by consumer high speed BB, *shaded by competitive intensity[2]*



- San Bernardino County appears to experience more intense competition due to the presence of multiple providers in a handful of cities, particularly Ontario, Upland, and Rancho Cucamonga
- Imperial County's demand center around El Centro sits far from urban areas, impacting BB availability and competitive intensity

Of those covered by high speed BB only a subset benefit from provider competition

SCAG members covered[1] by consumer high speed BB at entity level aggregation, *shaded by competitive intensity[2]*



Notes: 1) Availability based on company reported data to FCC on offerings by census block 2) Competitive intensity based on score driven by number of providers by broadband technology offering by census block, aggregated to city or county level; score cutoff for competitive intensity is 1.6; 3) An additional ~50% of Inglewood pop also has AT&T VDSL offering, which may provide HS BB, made more likely by AT&T's nearby offering of FTTH

Sources: US Census, FCC, Market Research, SCAG, SCAG team analysis

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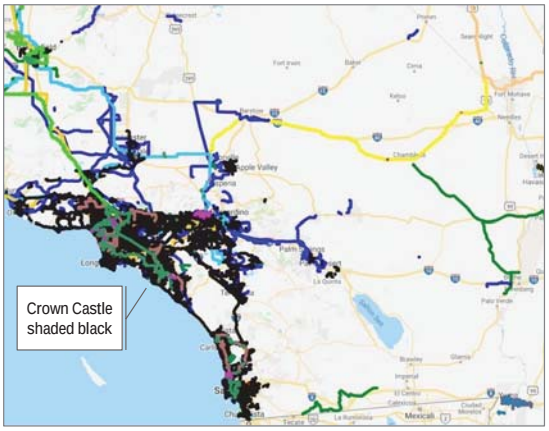
Long haul and middle-mile fiber provide the infrastructure that enables both the access networks for consumers and SCAG infrastructure connectivity

Long Haul Fiber

- Major fiber providers such as AT&T, CenturyLink, Level 3, Sprint, Windstream and Zayo have long-haul networks running alongside major interstates connecting the region such as I-5, I-15, I-10, I-8, I-40.
- Smaller players also have long-haul network assets in the service area.

Middle-Mile Fiber



- Outside of Los Angeles, San Bernardino and Irvine cities, middle-mile fiber presence in the rest of Riverside, San Bernardino and Imperial counties is relatively sparse
- Crown Castle has a very dense middle-mile network in the LA and San Bernardino region

Notes: Review of fiber located on interstate RoW is preliminary and not exhaustive
Source: Fiberlocator, Market Research, SCAG, SCAG team analysis

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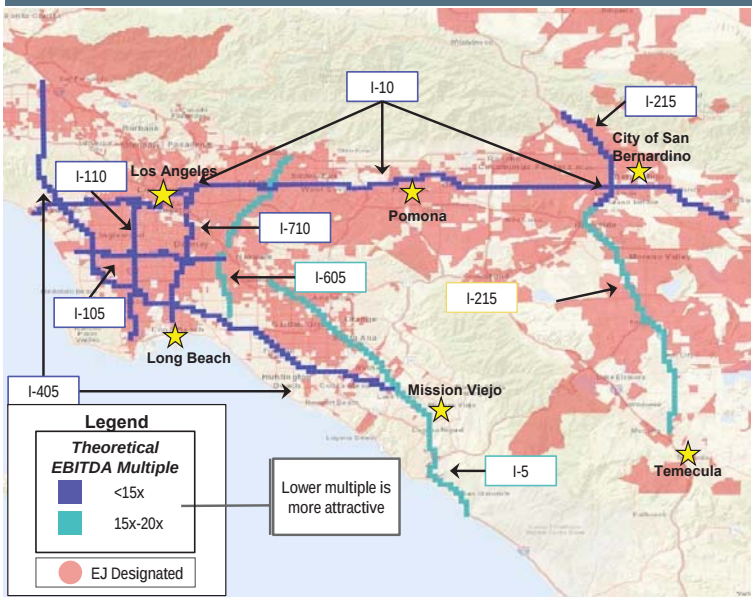
Executive Summary: SCAG Opportunities
Commercially attractive segments may encourage a private sector build for middle-mile fiber, a key enabler of high speed access broadband

Interstates in SCAG Service Area split by county, *shaded by theoretical run rate EBITDA multiple*



Segments that may be viable without public subsidy
(Investment to anticipated EBITDA run rate multiple <15x)

County	Interstate_ Name	CapEx/Run Rate EBTIDA (Idealized Multiple)	Total CapEx Per Mile
Los Angeles	I-10	13	$1.6M
	I-105	11	$1.6M
	I-110	13	$1.6M
	I-405	14	$1.6M
	I-710	12	$1.6M
San Bernardino	I-10	8	$0.4M
	I-215	9	$0.4M
Grand Total		***12***	***$1.3M***

Segments that may be viable with public subsidy
(Investment to anticipated EBITDA run rate multiple 15x-20x)

County	Interstate_ Name	CapEx/Run Rate EBTIDA (Idealized Multiple)	Total CapEx Per Mile
Los Angeles	I-605	19	$1.6M
Orange	I-5	18	$1.6M
	I-405	15	$1.6M
Riverside	I-215	17	$0.3M
Grand Total		***17***	***$1.3M***

Notes: Miles referenced are a simplified estimation of route miles based on assumption of rd.. length of 1 km =~.6 miles for every mgrs grid square; results of analysis have not yet been finalized and delivered
Sources: US Census, FHWA, FCC, Fiberlocator, OpencellID, CPUC, SCAG, Caltrans, Market Research, ITU, SCAG team analysis

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Target Metric

A run rate EBITDA multiple of 15x[1] serves as a cutoff filter to provide preliminary views on RoW commercial viability

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Commentary

- There is data available for a handful of deals for purchase of fiber routes announced around 2016 and 2017[1]
- Deal prices can be viewed through the lens of a forward year cash flow multiple, meaning that a buyer values a fiber route mile to be worth a certain number of years of future casfhlows[2]
- Of 10-15 deals reviewed[3] two were valued at a multiple of 15, six valued at a multiple between 10-14, and four below 10

- After incorporating simplifying assumptions, the above multiple can be used as a directional cutoff to identify RoW that may be commercially attractive based on a segment build cost equal to **15x run rate EBITDA**[4,5]

Illustrative Example

Metric	Caltrans District α	Caltrans District β
Estimated Wireline Capital Cost	$1,500k per mile	$300k per mile
Cutoff Multiple	**15x**	**15x**
Minimum EBITDA[4,5]	$100k per mile per year	$20k per mile per year

Notes: 1) Based on historical fiber deal values combined with simplified modeling assumptions; 2) One deal referenced herein was announced in 2015 ; 3) This is a simplified interpretation of the CF metric, and doesn't describe all details including assumed inflation, price changes, other value derived from an asset, etc.; 4) Only minimal information was available on the transactions, and the deals had a mix of metro and long haul fiber; 5) EBITDA is used as a directional proxy for cash-flow, and uses simplified assumption of no ramp period, for customer acquisition, construction, etc.; 6) The small cell lease direct contribution to financials is included in EBITDA based on the observation that it has a far less meaningful impact than wireline; Caltrans districts blinded

Sources: S&P Market Intelligence, Caltrans, Market Research, SCAG team analysis