



Reshaping Wireless Competition: The Role of the L-Band

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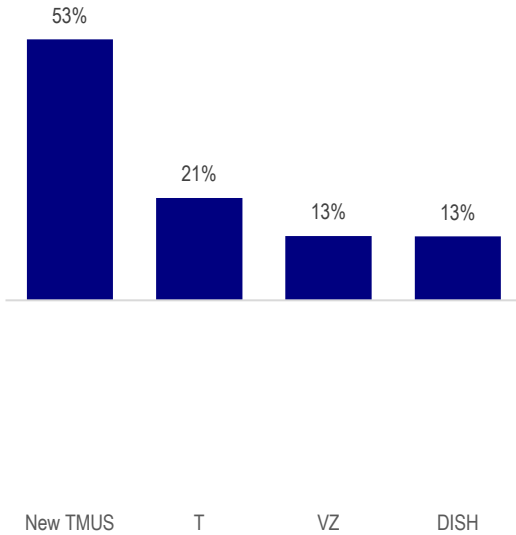
philip.burnett@newstreetresearch.com

Conclusions

The Spectrum Imbalance

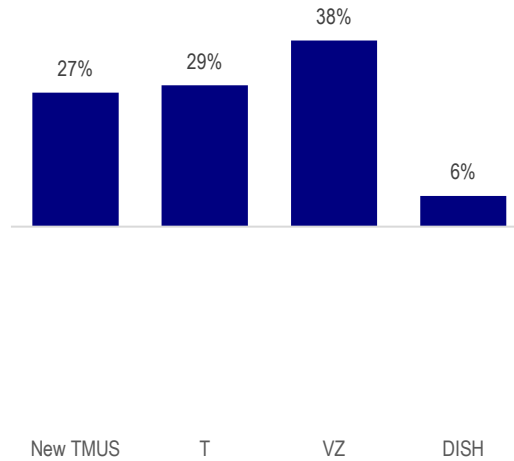
Current Capacity Share

% of Capacity Below 6 GHz



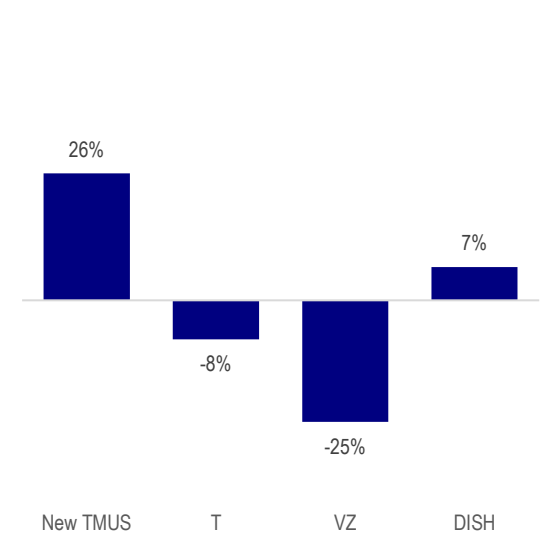
Current Revenue Share

% of Wireless Service Revenue



Revenue at Risk

%, Capacity Share less Revenue Share

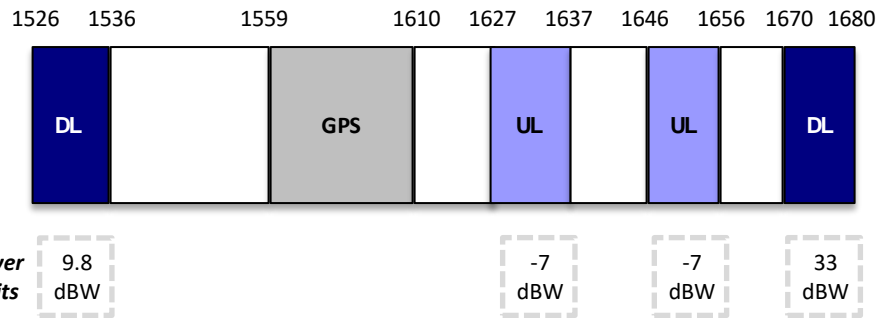


Source: Company data, New Street Research estimates

What The L-Band Brings

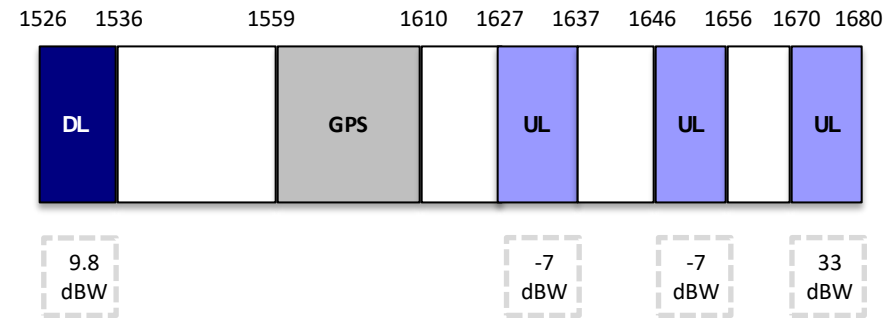
L-Band Paired Configuration

MHz



L-Band Supplemental Uplink Configuration

MHz

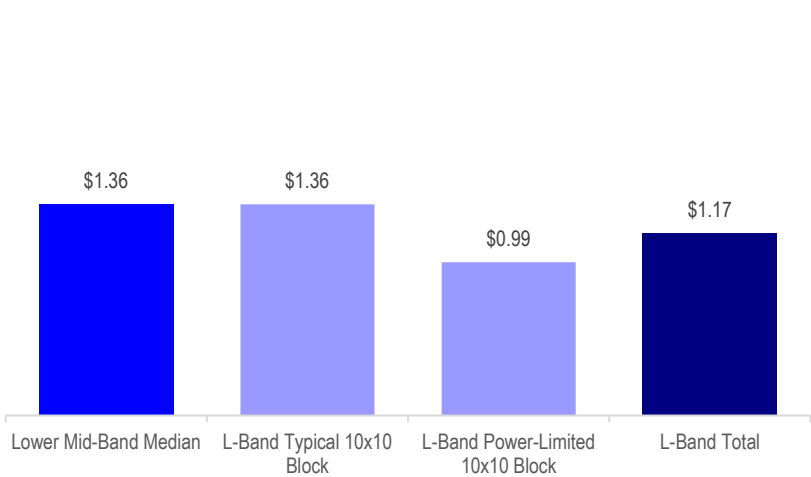


Source: Company data, New Street Research estimates

Use Case #1: Paired Lower Mid-Band Spectrum

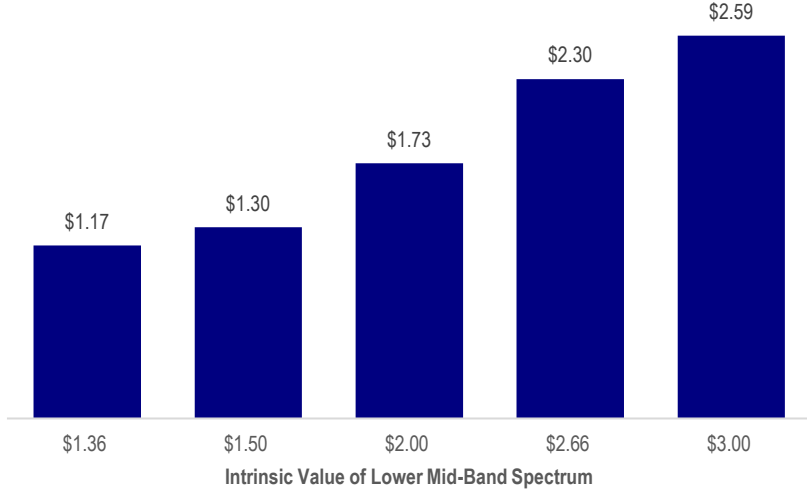
L-Band Spectrum Valuation

\$ / MHz-POP



L-Band Spectrum Valuation Sensitized to Intrinsic Value of Lower Mid-Band Spectrum

\$ / MHz-POP



Source: Company data, New Street Research estimates

Use Case #2: Supplemental Uplink Spectrum

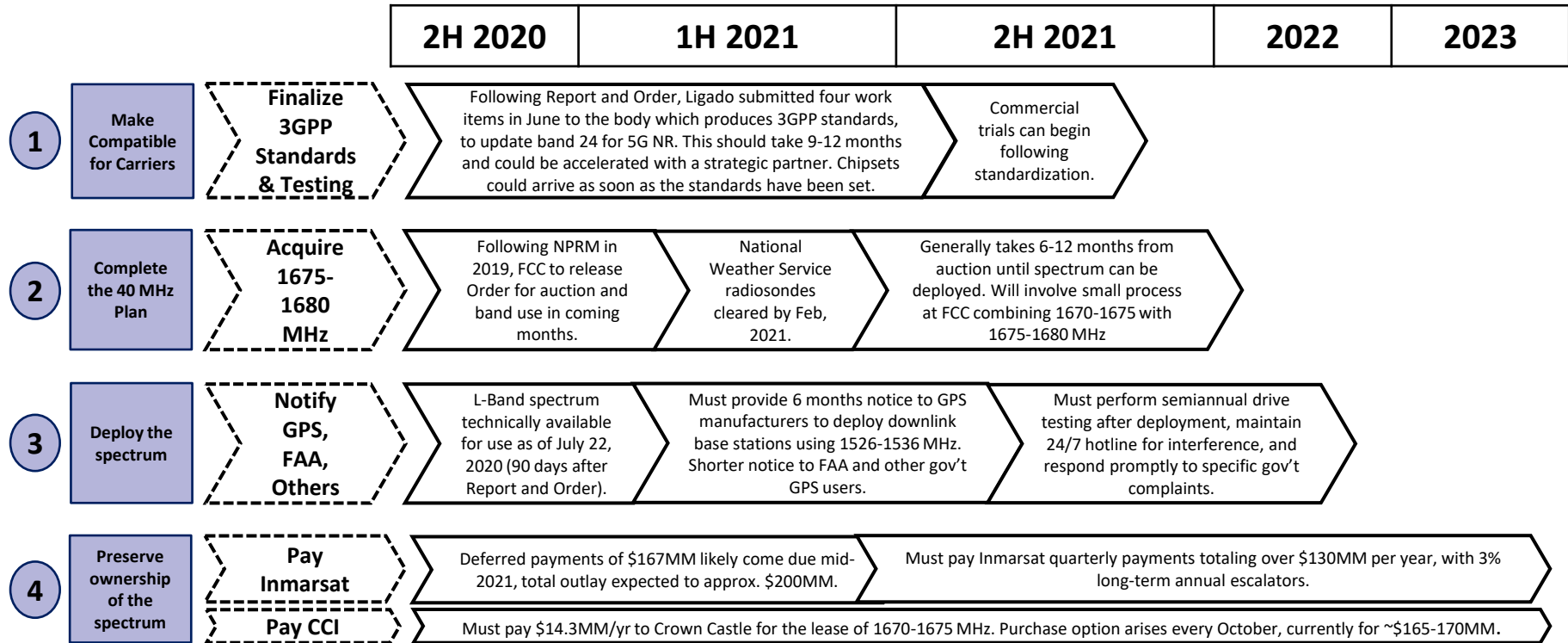
Value of L-Band With C+L Configuration

\$, millions



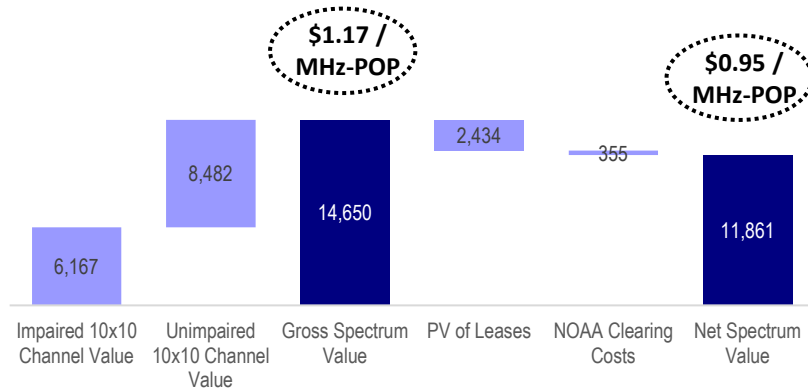
Source: Company data, New Street Research estimates

The Path to Value

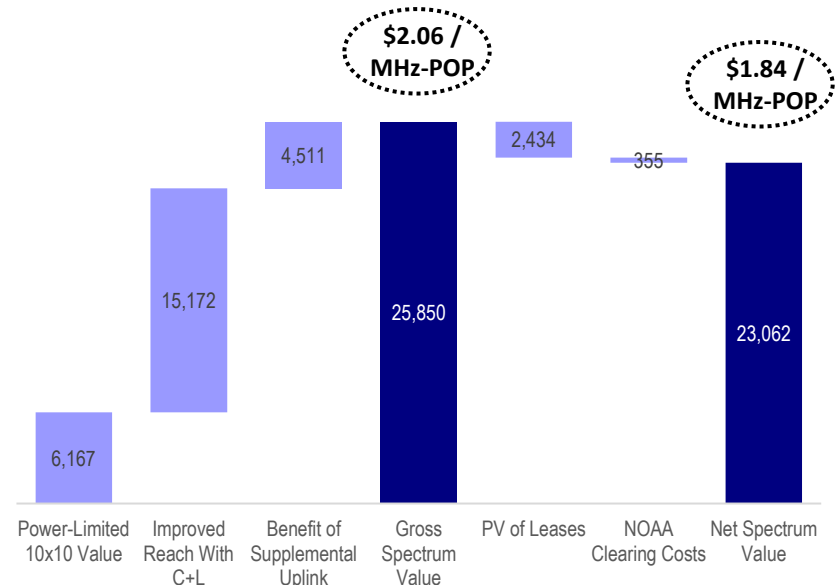


The Value Of The L-Band To Ligado

Ligado Paired Spectrum Valuation \$, millions



Ligado Supplementary Uplink Spectrum Valuation \$, millions

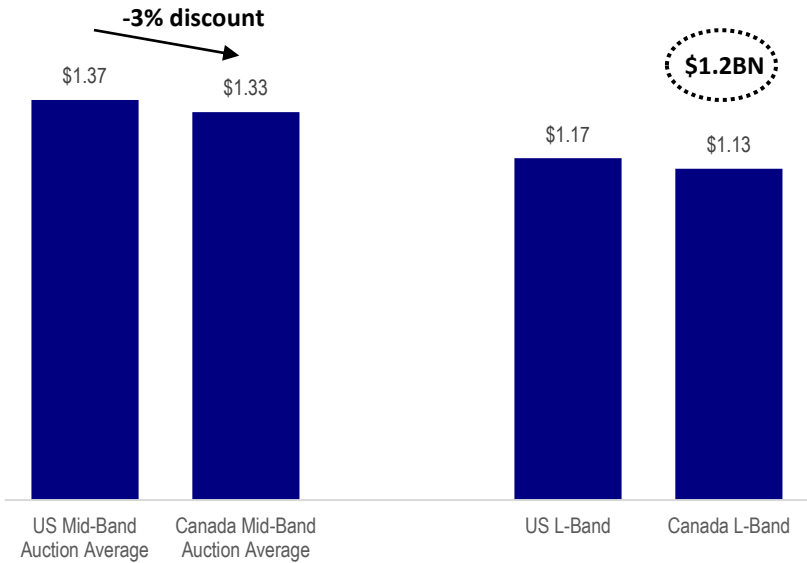


Source: Company data, New Street Research estimates; According to Debtwire, the lease terms with Inmarsat were amended in July 2020. On our estimates, the NPV of the amended lease would be \$1.0BN, down from \$2.3BN under the prior terms. We use the prior terms for valuation purposes because the amended lease terms have not been publicly disclosed and they are contingent on financial payouts; however, this is likely conservative;

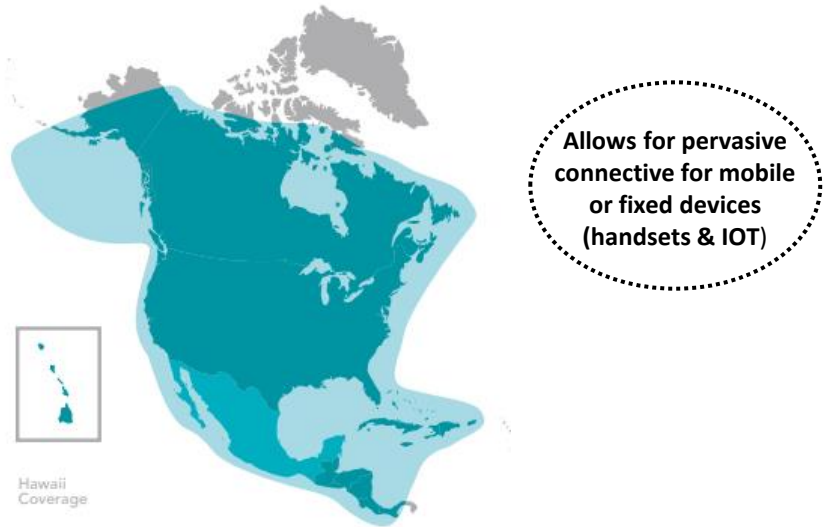
Other Sources Of Value

Value of Canadian L-Band Spectrum¹

\$ / MHz-POP



Satellite Network Provides Ubiquitous Coverage of North America



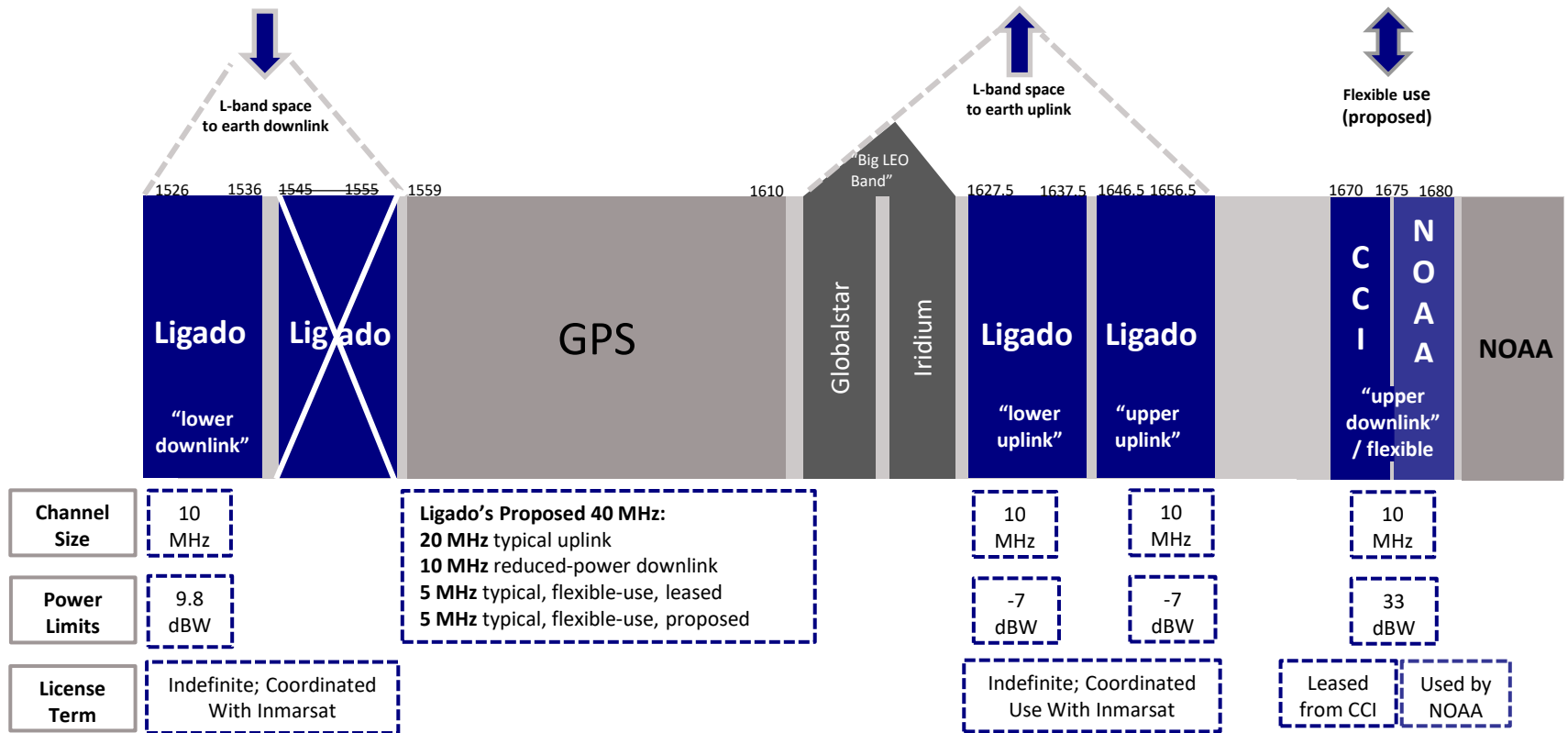
¹ Applying traditional discount to the value we ascribe to power limited spectrum in the US may not be accurate given that the impact of power limits is determined by the distribution of population density, which may be very different in Canada. Conversely, the added reach of the L-Band may be of greater value in Canada.
 Source: Company data, New Street Research estimates

The Controversies

- 1 Using \$1.36 / MHz-POP as a starting point for valuing the L-Band
- 2 Impact of power limits on reach and value of the lower downlink
- 3 Impact of supply on valuation (does anybody care now)
- 4 Impact of massive MIMO and beamforming on reach
- 5 Capacity improvement from supplemental uplink remains uncertain
- 6 Carriers may have enough supplemental uplink among existing bands
- 7 Is there more than one bidder

Setting the stage

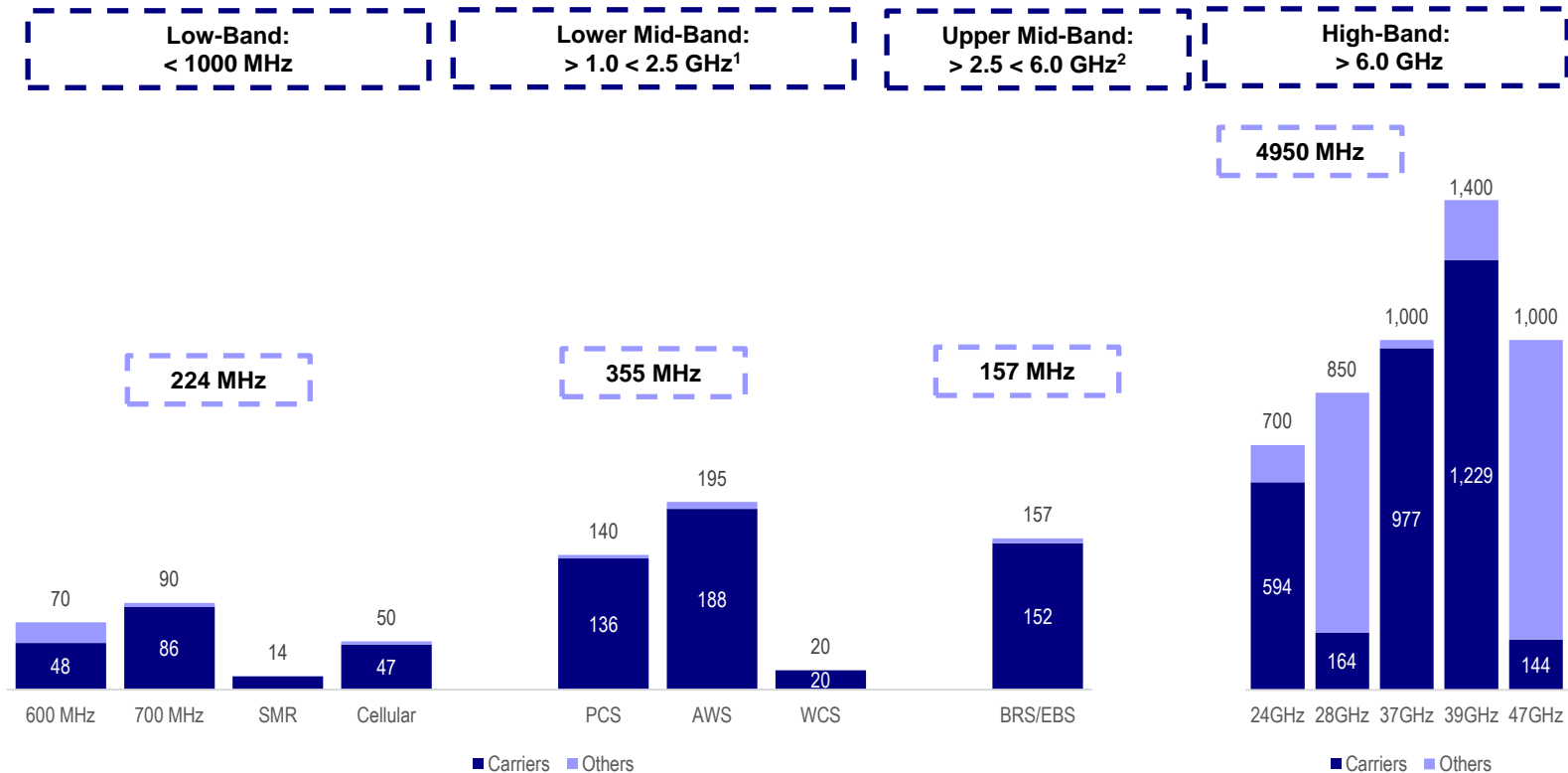
License Terms and Limitations



Source: New Street Research estimates

The Spectrum of Spectrum

Spectrum Licensed Today MHz

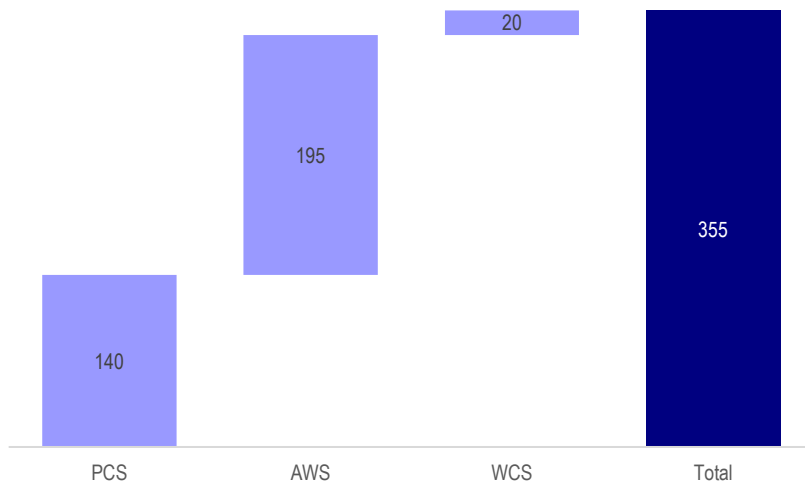


¹The FCC spectrum screen recognizes “lower mid-band” from 1-2GHz, and “upper mid-band” from 2-6GHz. ²However, globally, “mid-band” spectrum is from 3-24GHz (above which is mmWave); we think the most logical reconciliation of these evolving definitions is reflected above (with further segmentation for mmWave, above 24GHz, from high-band above 6 GHz). Source: Company data, New Street Research estimates; “Carriers” includes T-Mobile, Verizon, AT&T and Dish.

The Value of Lower Mid-Band Spectrum

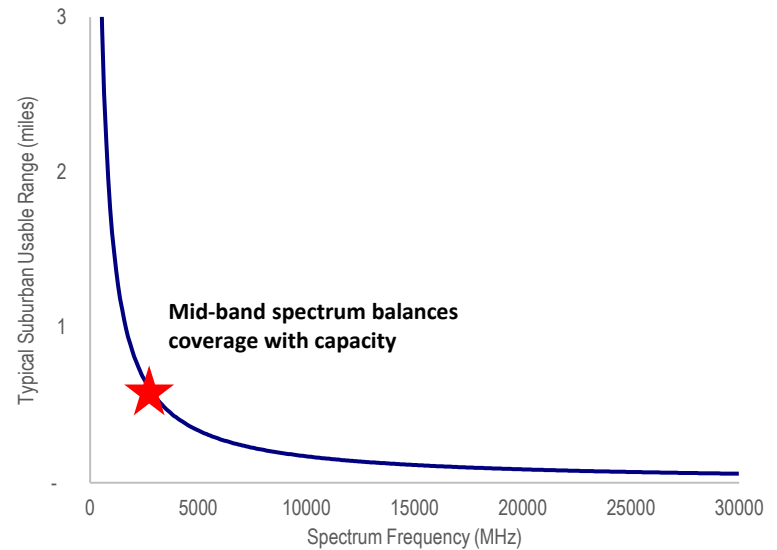
Lower Mid-Band Spectrum

MHz; national average



Range Vs. Frequency

Miles and MHz; Suburban deployment

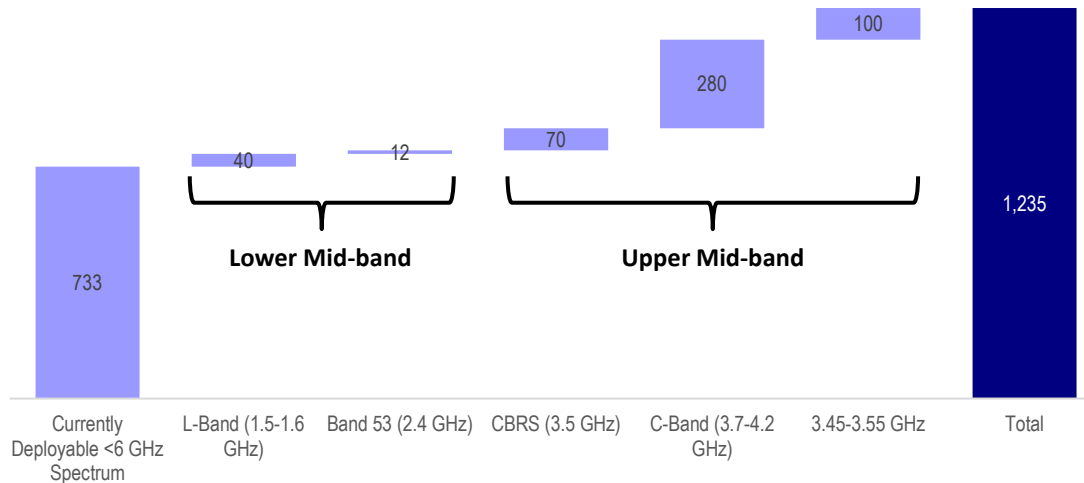


Source: Company data, New Street Research estimates

Supply - 500 MHz of Spectrum Coming To Market

Total Spectrum Coming To Market Below 6 GHz

MHz, national average



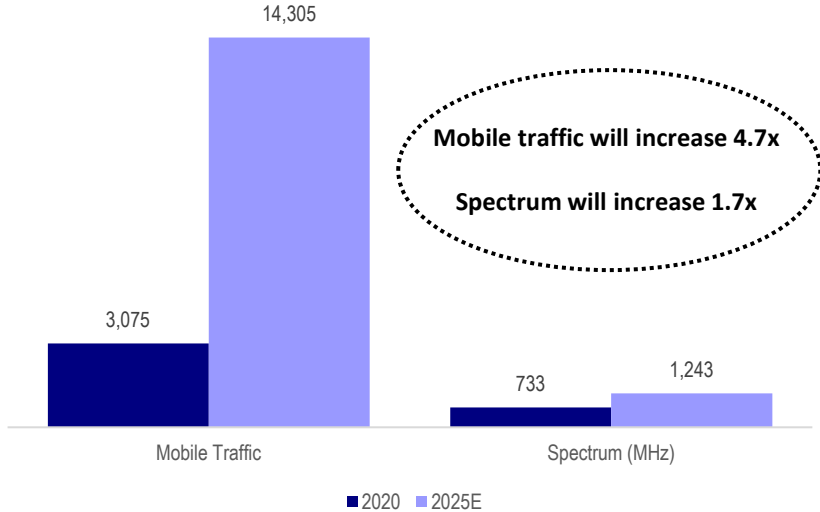
¹ The DoD agreed to make 3.45-3.55MHz available for commercial use subject to sharing rules that, if adopted, could result in an auction in December 2021 at the earliest.

Source: Company data, New Street Research estimates

Demand - Spectrum Distributed Unevenly Across Carriers

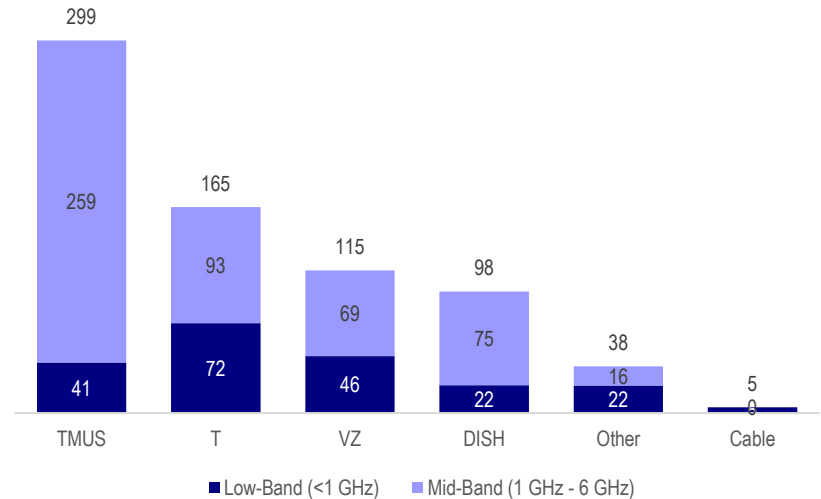
Mobile Traffic & Spectrum Growth

Traffic in petabytes per month; Spectrum in MHz



Spectrum Holdings By Carrier Below 6GHz

MHz, national average



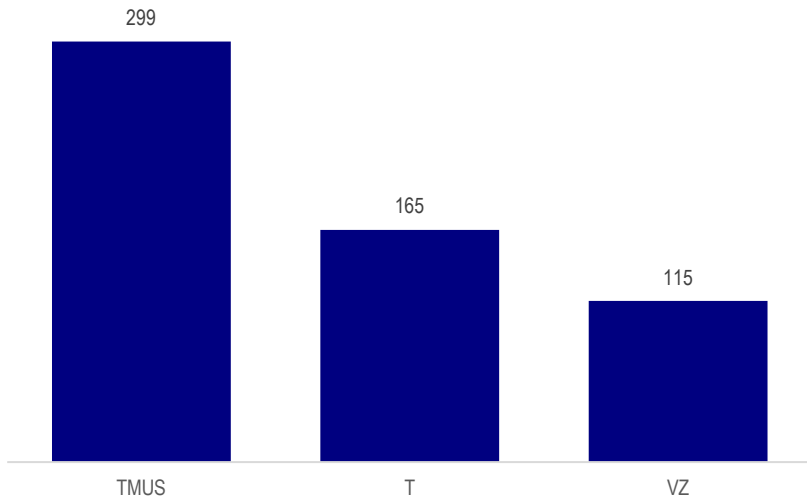
¹ This is for spectrum below 6GHz. We ignore millimeter wave spectrum because it has limited utility.

Source: Company data, New Street Research estimates

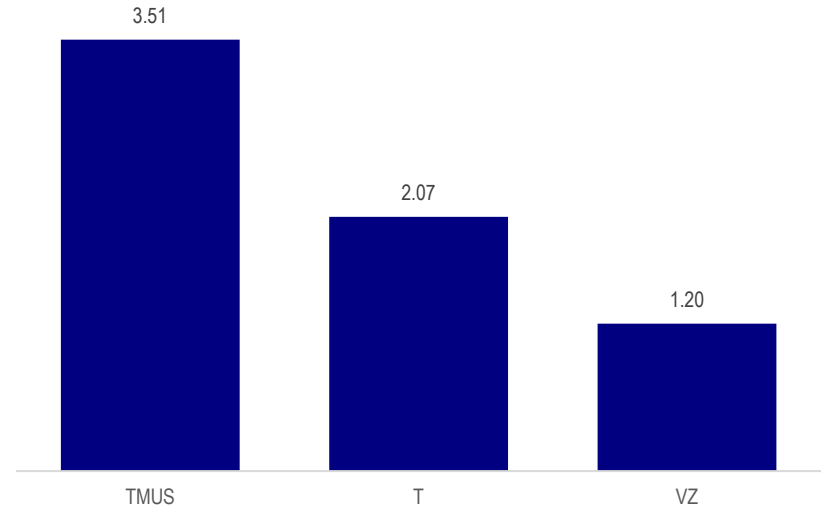
Competitive Dynamics

T-Mobile Has More Spectrum Than Peers...

Spectrum Holdings By Carrier
MHz, national average¹



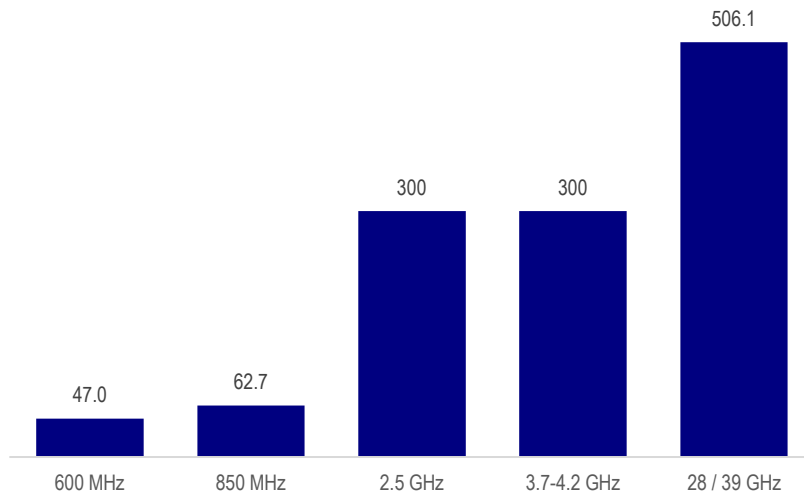
Spectrum Holdings Per Sub By Carrier
MHz per millions of subs



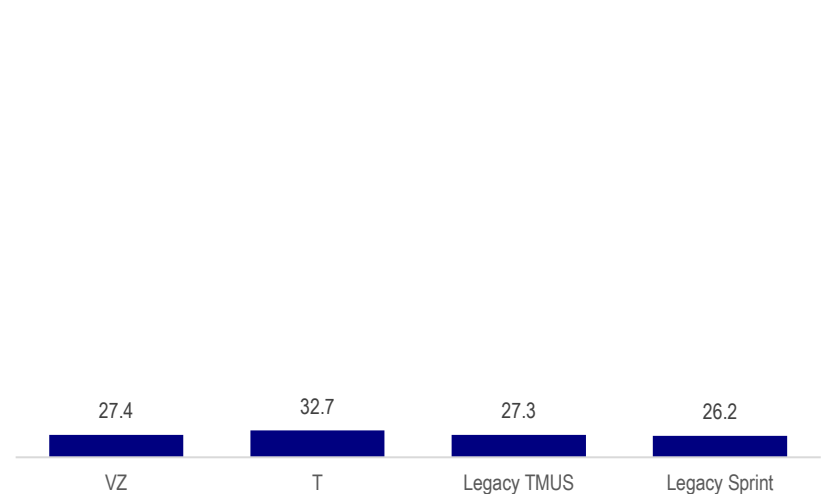
Source: Company data, New Street Research estimates

...And They Have Better Spectrum...

5G Average Speeds¹
Mbps



4G Average Speeds By Carrier²
Mbps



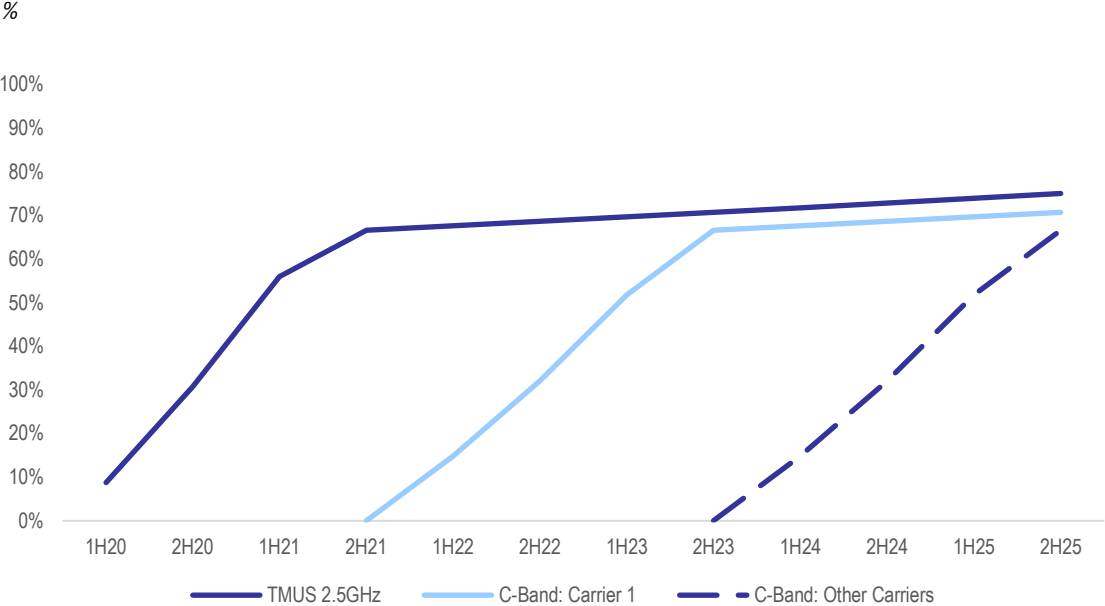
¹ OpenSignal 5G speeds from T-Mobile on 600MHz, AT&T on 850MHz, and Verizon on millimeter wave spectrum from early 2020. The amount of spectrum in use is different in each case. Open Signal data for Sprint's network on 2.5 GHz showed 114Mbps; however, we don't think that reflects likely speeds in T-Mobile deployment.

² OpenSignal 4G speeds across all spectrum bands by carrier

Source: [Opensignal](https://www.opensignal.com/), Company data, New Street Research estimates

...And They Have A Timing Advantage...

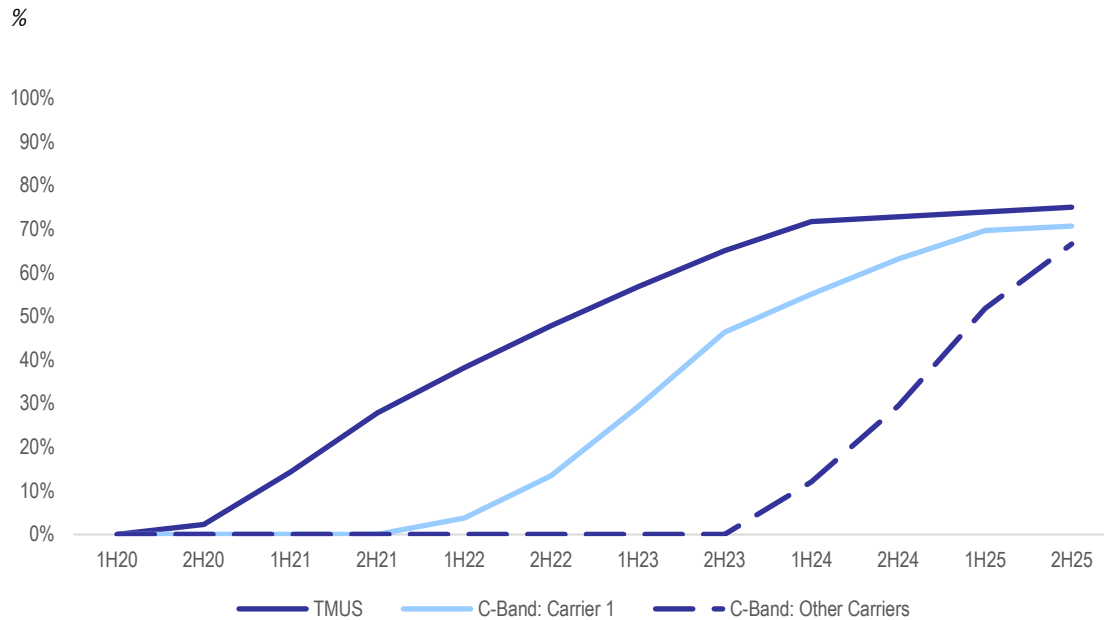
5G POP Coverage on Upper Mid-Band Spectrum



Source: Company data, New Street Research estimates

...And This Is All Happening At A Time When 5G Will Matter

Share of Subscribers On Fast 5G Network¹



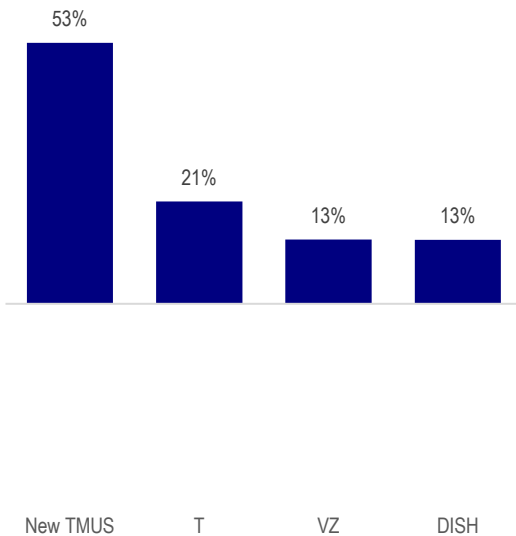
1. This combines POP coverage with upper mid-band spectrum and 5G handset penetration. We assume POP coverage never gets to 100% on upper-mid-band.

Source: Company data, New Street Research estimates

Market Share Will Shift...

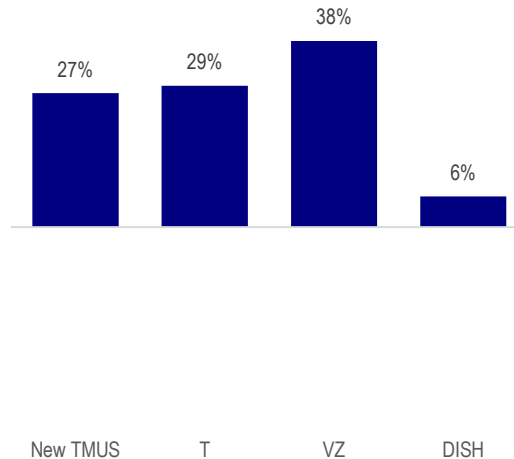
Current Capacity Share

% of Capacity Below 6 GHz



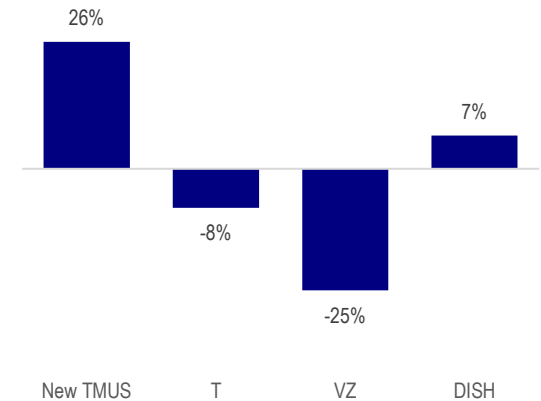
Current Revenue Share

% of Wireless Service Revenue



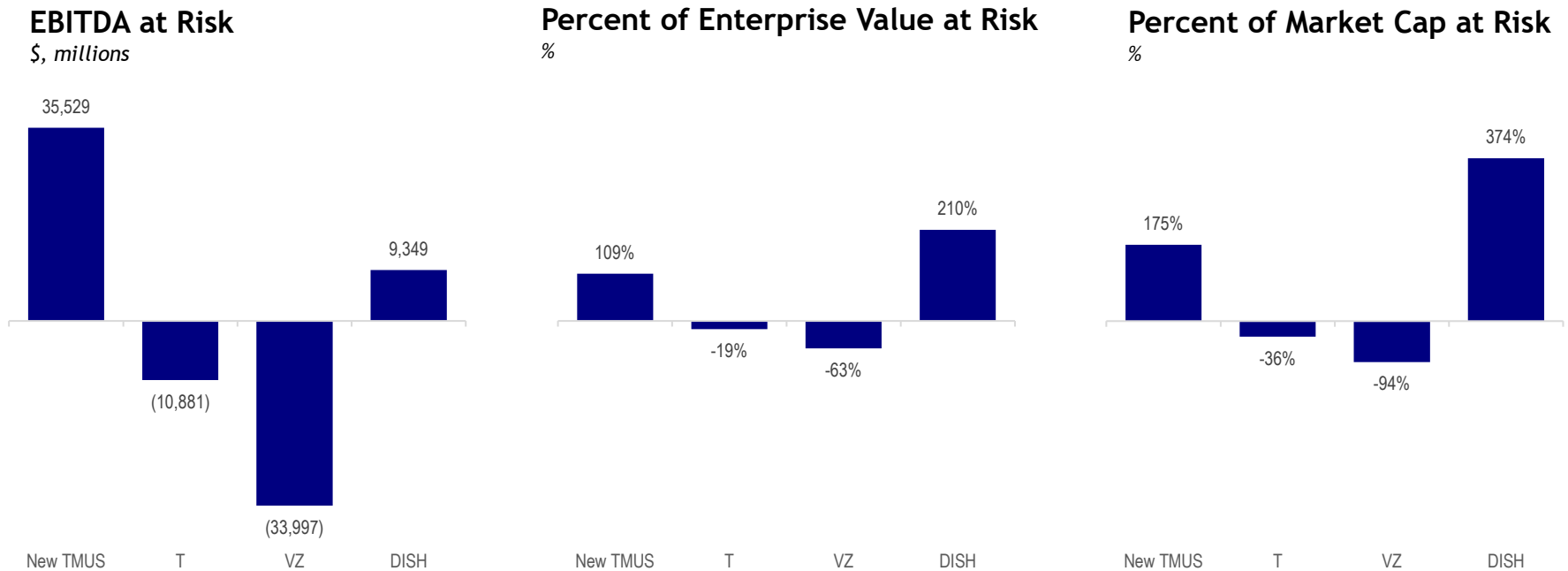
Revenue at Risk

%, Capacity Share less Revenue Share



Source: Company data, New Street Research estimates

...And Value Will Shift With It

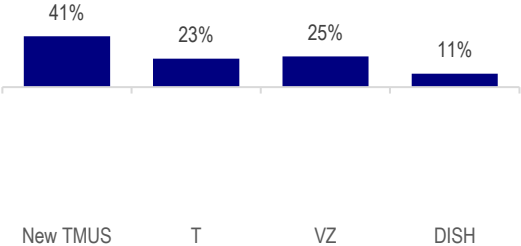


Source: Company data, New Street Research estimates

The C-Band Could Help (Eventually)...

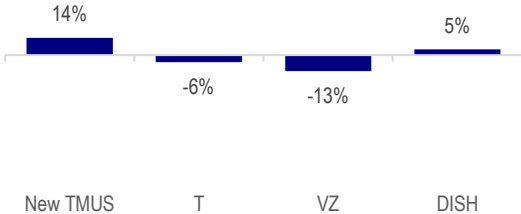
Capacity Share PF C-Band

% of Capacity Below 6 GHz



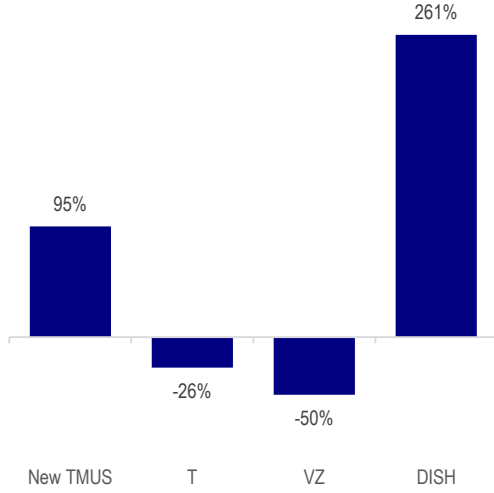
Market Share at Risk

%



Percent of Market Cap at Risk

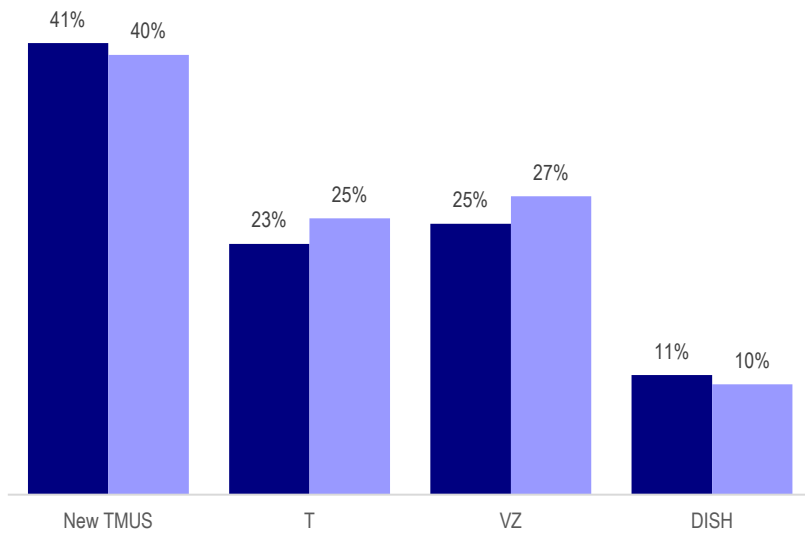
%



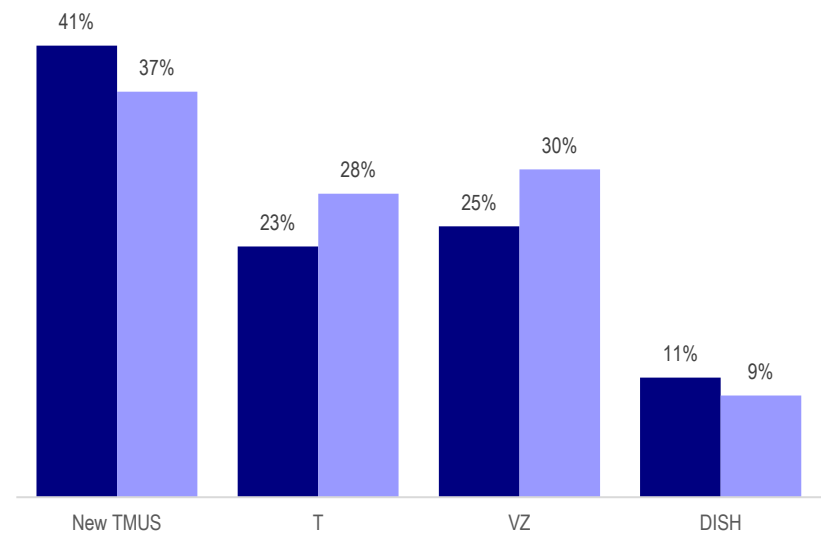
Source: Company data, New Street Research estimates

...And The L-Band Could Help Too

Capacity Share With L-Band In Paired Configuration¹
% of Capacity Below 6 GHz



Capacity Share With L-Band In C+L Configuration¹
% of Capacity Below 6 GHz



¹ Assumes either Verizon or AT&T gain capacity benefit from L-Band

Source: Company data, New Street Research estimates

The Other Side of Competition (Scare Resources)

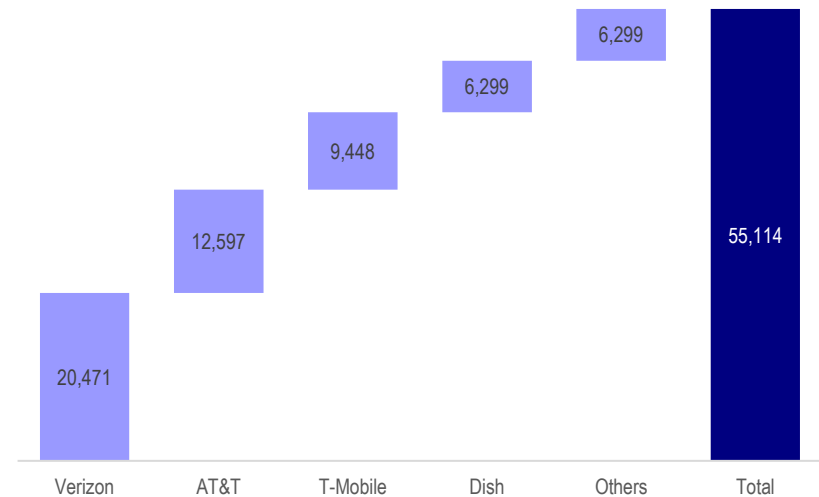
Leverage Threshold By Carrier

Net debt / EBITDA Multiple

	Leverage Target	Leverage Today
Verizon	1.75x-2.0x	2.0x
AT&T	2.0x-2.25x	2.6x
T-Mobile	2.5x	3.0x
Dish	N/A	3.7x

Available Capacity By Carrier

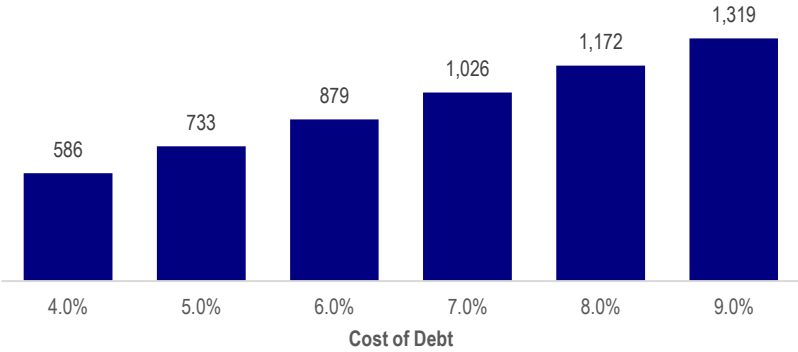
\$, millions



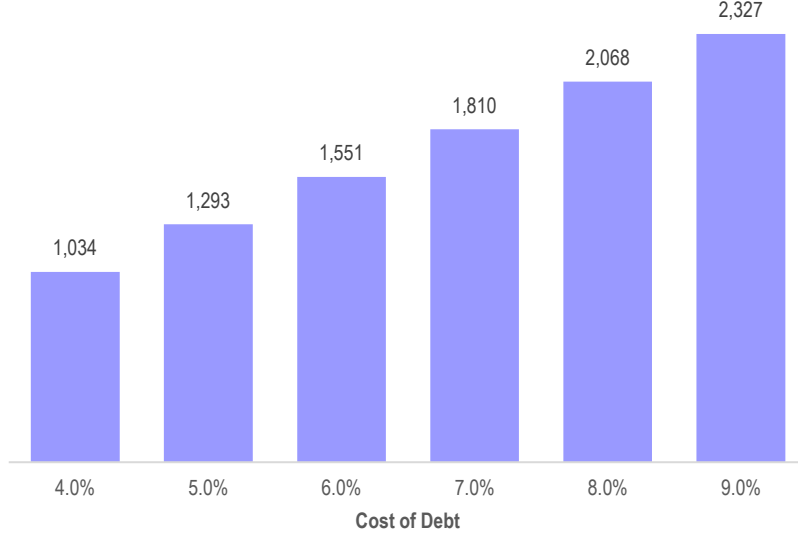
Source: Company data, New Street Research estimates

The Advantage of Flexibility

**Annual Lease Costs At Different Cap Rates:
Paired Valuation**
\$, millions



**Annual Lease Costs At Different Cap Rates:
Supplemental Uplink Valuation**
\$, millions



Source: Company data, New Street Research estimates

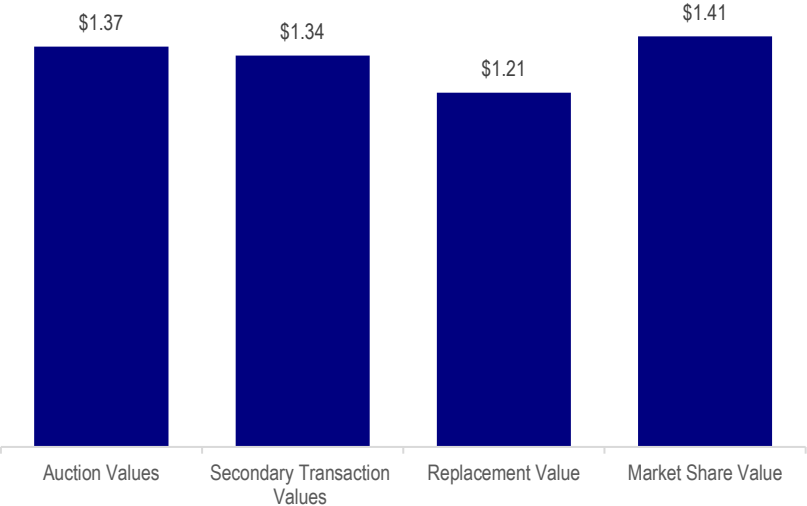
Valuing The L-Band

Use Case #1: Paired Configuration

L-Band Paired Configuration Valuation Summary

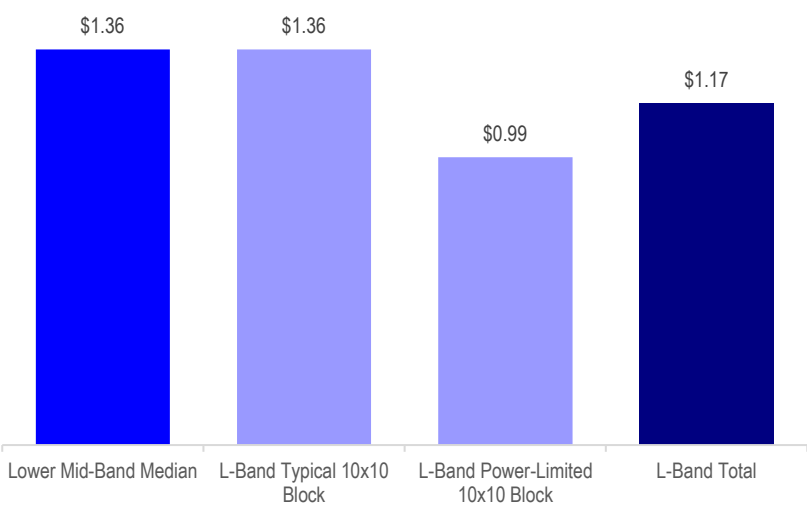
Lower Mid-Band Spectrum Valuation

\$ / MHz-POP



L-Band Spectrum Valuation

\$ / MHz-POP



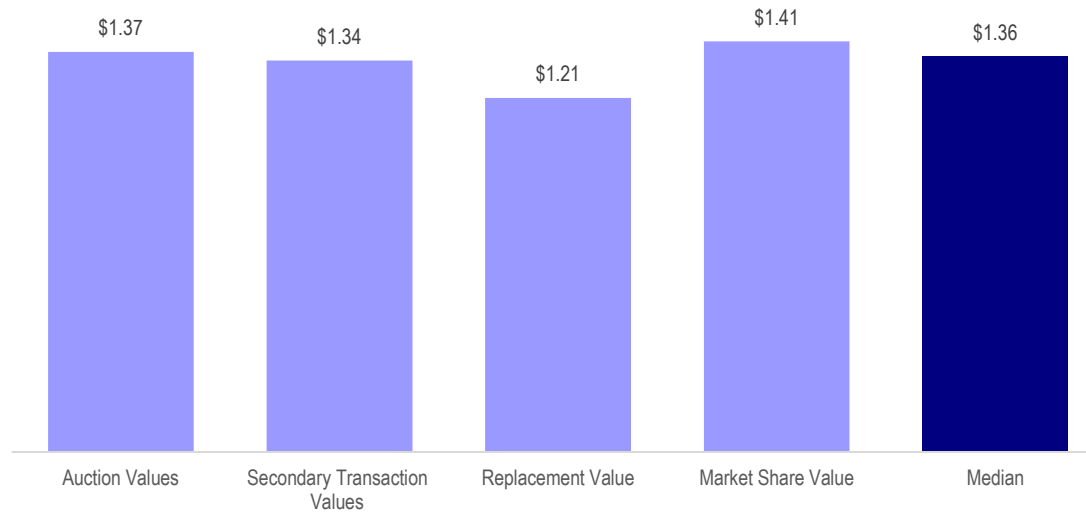
Source: Company data, New Street Research estimates

Five Steps To Valuing The Paired Spectrum Use Case

- 1 Intrinsic value of lower mid-band
- 2 Reach of lower mid-band
- 3 Impact of power limits on range & capacity
- 4 Impact of power limits on value
- 5 Summing the parts

Step #1: Intrinsic Value Of Lower Mid-Band Spectrum

Intrinsic Value of Lower Mid-Band Spectrum
\$/ MHz-POP



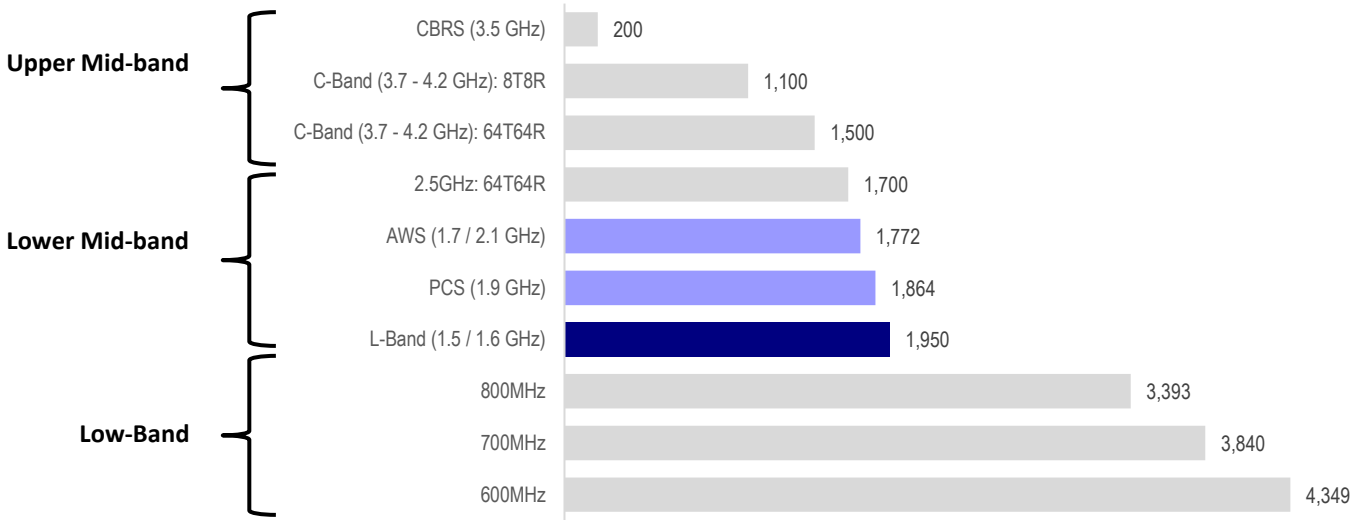
Controversy #1: Starting price too low

Source: Company data, New Street Research estimates

Step #2: The Reach Of Lower Mid-Band Spectrum

Typical Cell Radius By Band

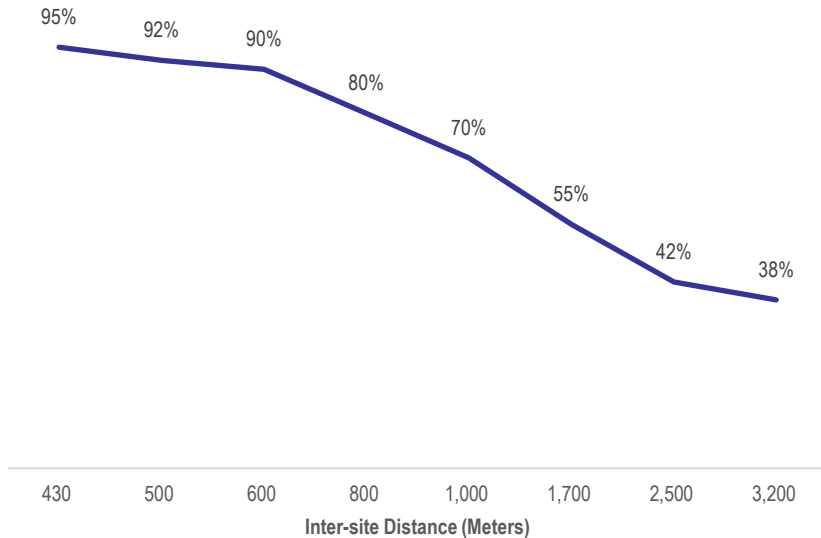
Meters



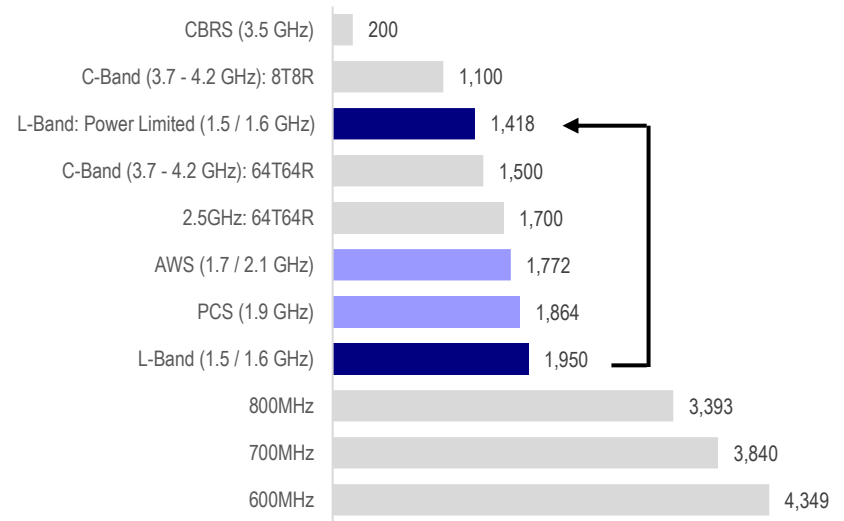
Source: Company data, TeleWorld Solutions, New Street Research estimates

Step #3: Impact Of Power Limits On Range & Capacity

Reduction In Channel Capacity Of Power Limited Spectrum By Inter-site Distance¹
%



Typical Cell Radius By Band
Meters

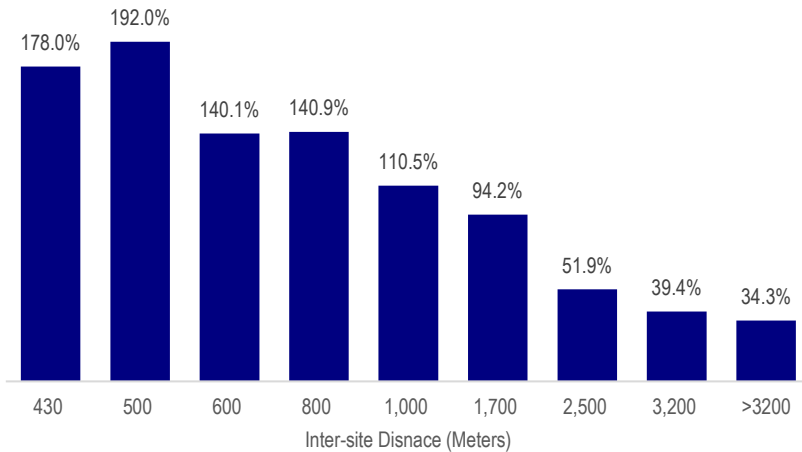


Controversy #2: Impact of power limits on reach

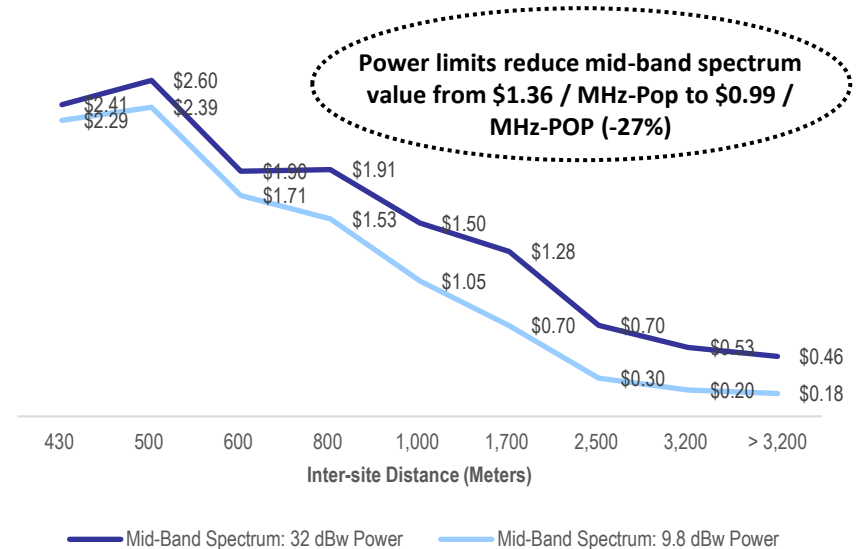
¹ 9.8 dBW Channel Capacity relative to 32 dBW Channel Capacity
Source: Nokia, Company data, New Street Research estimates

Step #4: Impact Of Power Limits On Value

AWS-3 Prices Relative to National Average
%



Mid-Band Spectrum Prices: Power Adjusted
\$/ MHz-POP

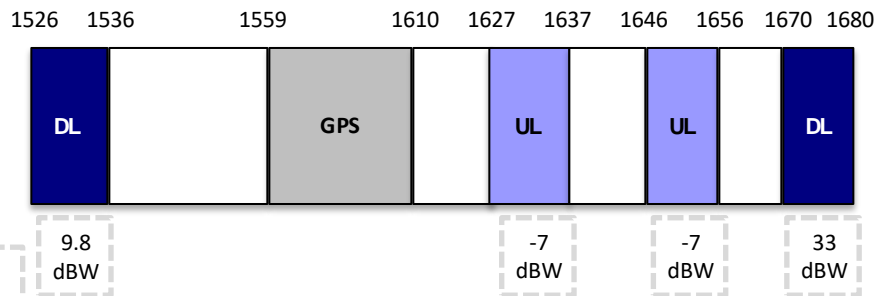


Source: Company data, New Street Research estimates

Step #5: L-Band Paired Configuration Sum Of The Parts

L-Band Paired Configuration & Valuation

\$, millions

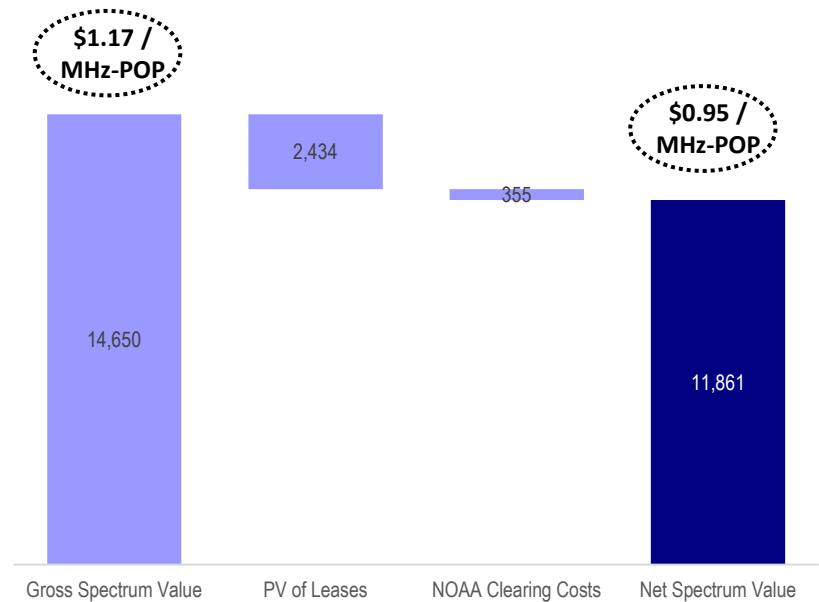


Block	MHz	POPs	\$ / MHz- Value	
			POP (\$MM)	
1526-1536 (DL) x 1646-1656 (UL)	20	313	\$0.99	6,167
1670-1680 (DL) x 1627-1637 (UL)	20	313	\$1.36	8,482
Total	40	313	\$1.17	14,650

Power Limits

Ligado Paired Spectrum Valuation

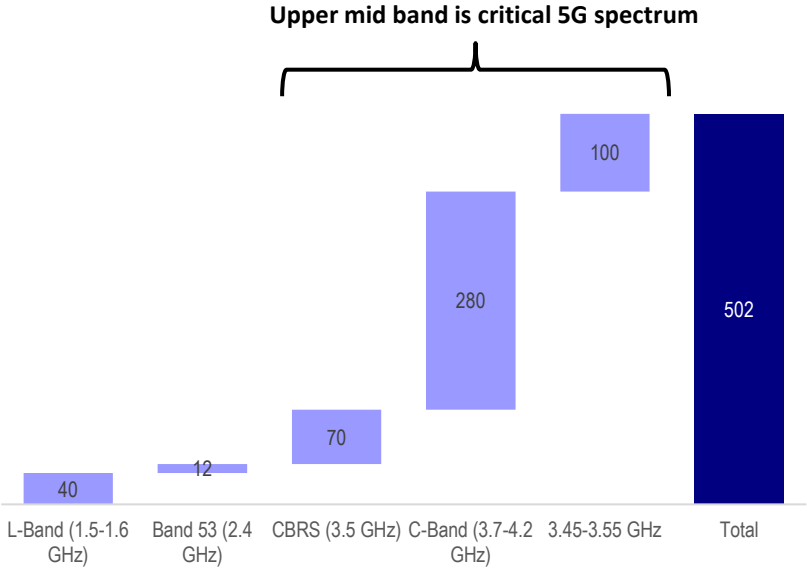
\$, millions



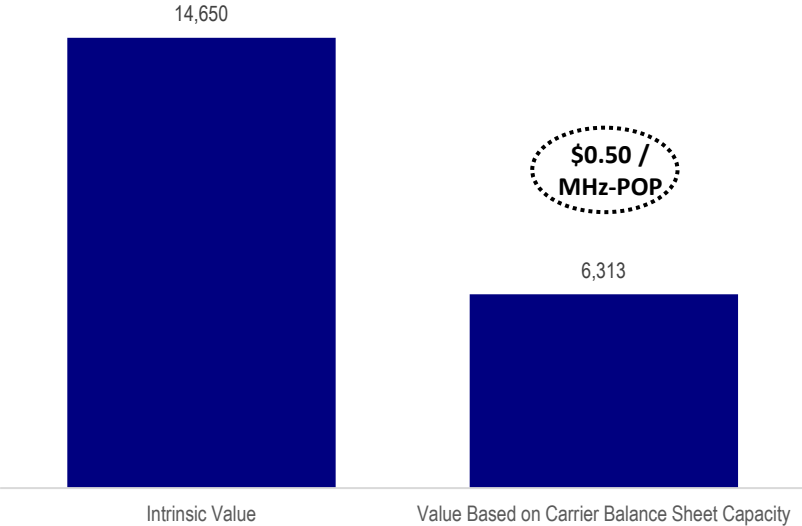
¹ According to Debtwire, the lease terms with Inmarsat were amended in July 2020. On our estimates, the NPV of the amended lease would be \$1.0BN, down from \$2.3BN under the prior terms. We use the prior terms for valuation purposes because the amended lease terms have not been publicly disclosed and they are contingent on financial payouts; however, this is likely conservative;

Key Controversy: Timing

Total Spectrum Coming To Market Below 6 GHz
MHz, national average



L-Band Valuation Based On Carrier Balance Sheet Capacity Today
\$, millions



Controversy #3: The impact of supply on value

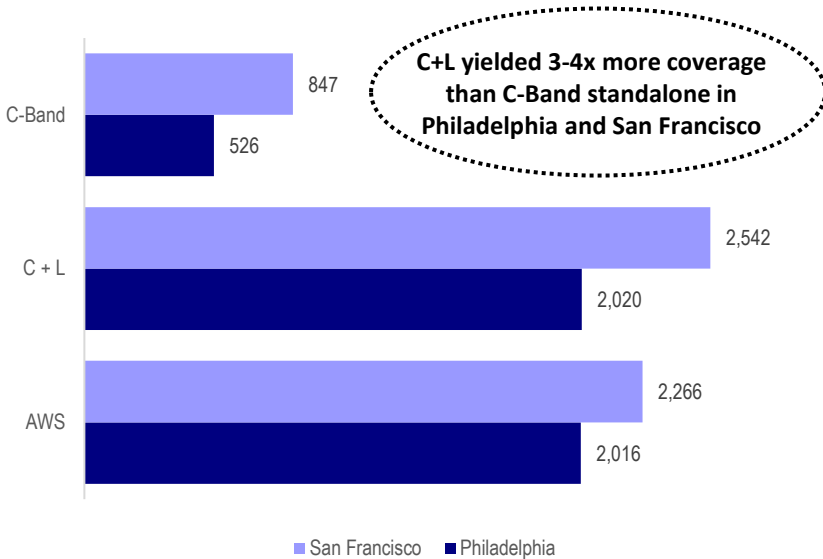
Source: Company data, New Street Research estimates

Valuing The L-Band

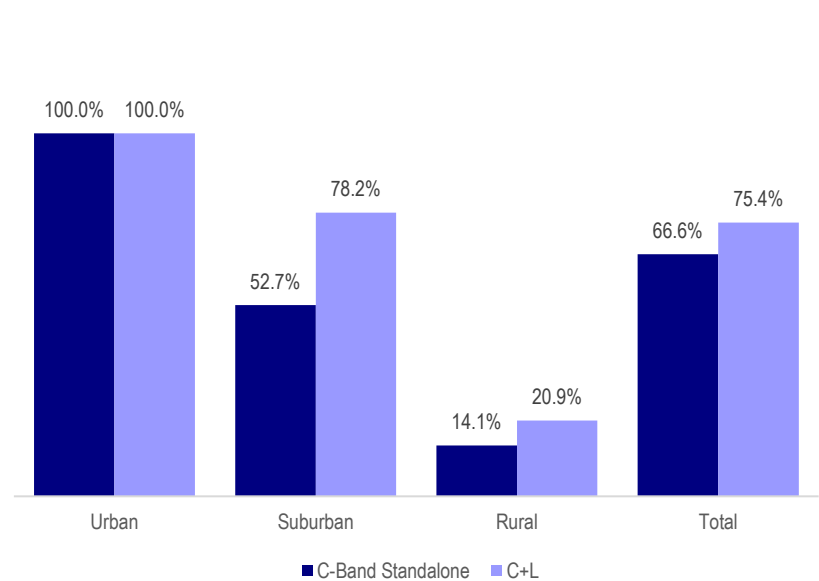
Use Case #2: Supplemental Uplink Configuration

Pairing C-Band With Lower Frequency Uplink Extends The Range...

C+L Coverage Area Relative To Standalone C-Band
Square kilometers



POP Coverage: C-Band Standalone vs. C+L
%



Source: TeleWorld Solutions, Company data, New Street Research estimates; Note that these coverage estimates focus on outdoor coverage. Indoor coverage will be lower, with material 'dead zones', which will be more common for higher frequency bands.

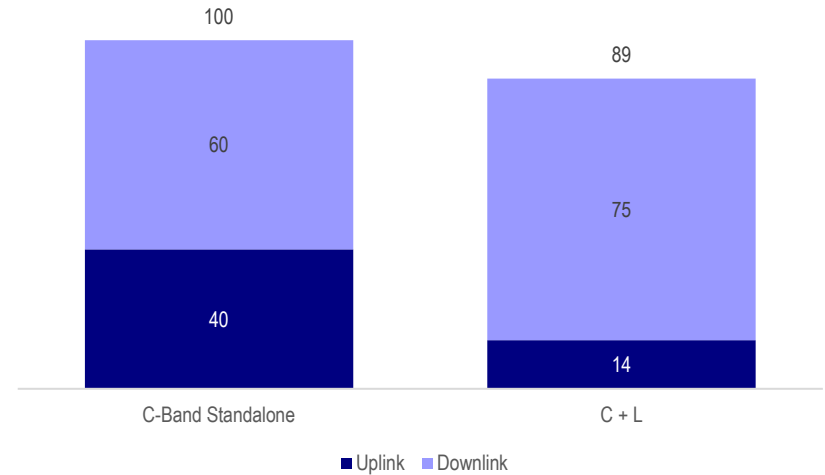
...And May Increase Capacity Too, Though This Is Uncertain

C+L Capacity Enhancement¹

Config 5 has 8 downlink subframes – a 25% increase over Config 3 with 6

Uplink-Downlink Configuration	Uplink-to-Downlink Switch-Point Periodicity	Subframe Number									
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Capacity Equivalency: C+L vs. Standalone C-Band²



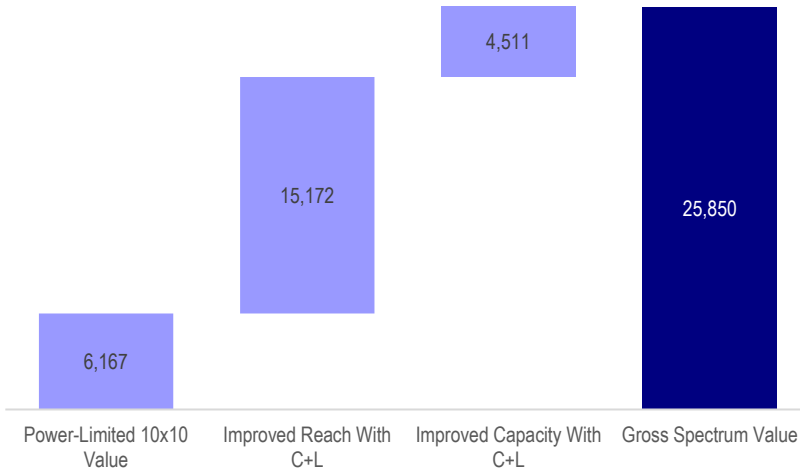
¹ It is unclear if an operator will be able to operate in C-Band configuration 5 unless all operators synchronize to this configuration. We expect most operators will opt for configuration 3.

² See Slide 91 in the appendix for more details on the 'exchange rate' between C-Band standalone and C+L.

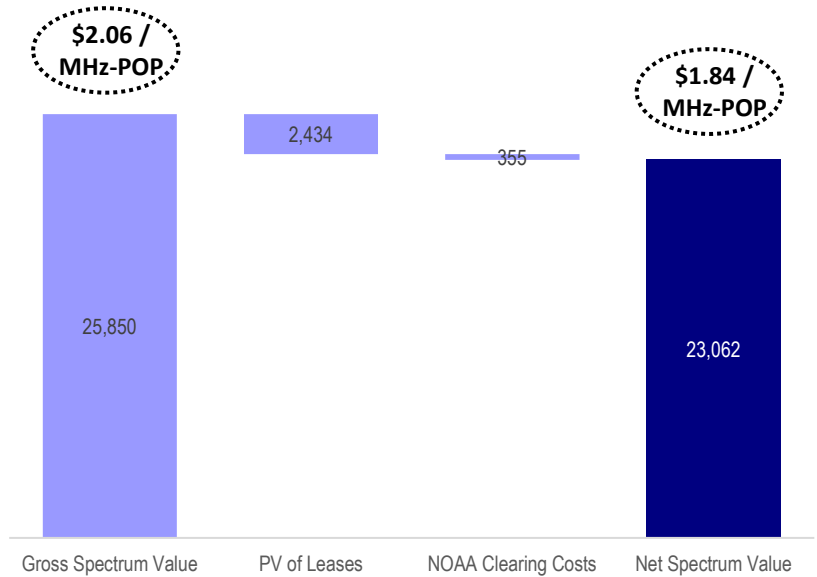
Source: Company data, New Street Research estimates

Supplemental Uplink Configuration Valuation Summary

Value of L-Band With C+L Configuration
\$, millions



Ligado Value With C+L Configuration
\$, millions



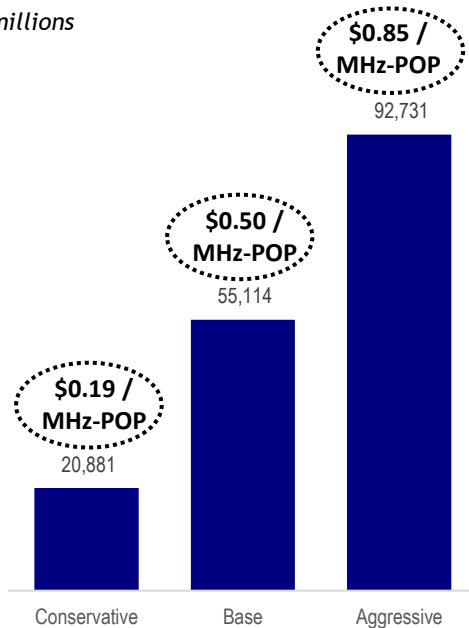
¹ According to Debtwire, the lease terms with Inmarsat were amended in July 2020. On our estimates, the NPV of the amended lease would be \$1.0BN, down from \$2.3BN under the prior terms. We use the prior terms for valuation purposes because the amended lease terms have not been publicly disclosed and they are contingent on financial payouts; however, this is likely conservative;

The Six Steps To Valuing The Supplemental Uplink Use Case

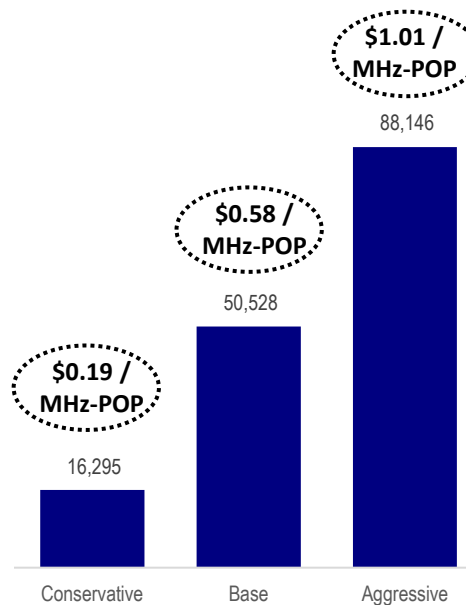
- 1 Intrinsic value of upper mid-band
- 2 Reach of upper mid-band
- 3 Impact of supplemental uplink on reach
- 4 Valuing the improvement in reach
- 5 Impact of supplemental uplink on capacity
- 6 Summing the parts

Step #1: The Intrinsic Value Of Upper Mid-Band

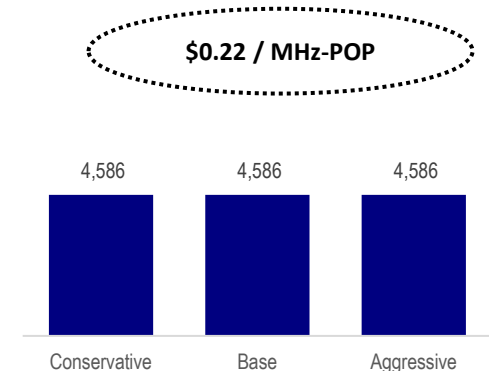
Total C-Band & CBRS Auction Proceeds
\$, millions



Implied C-Band Auction Proceeds
\$, millions



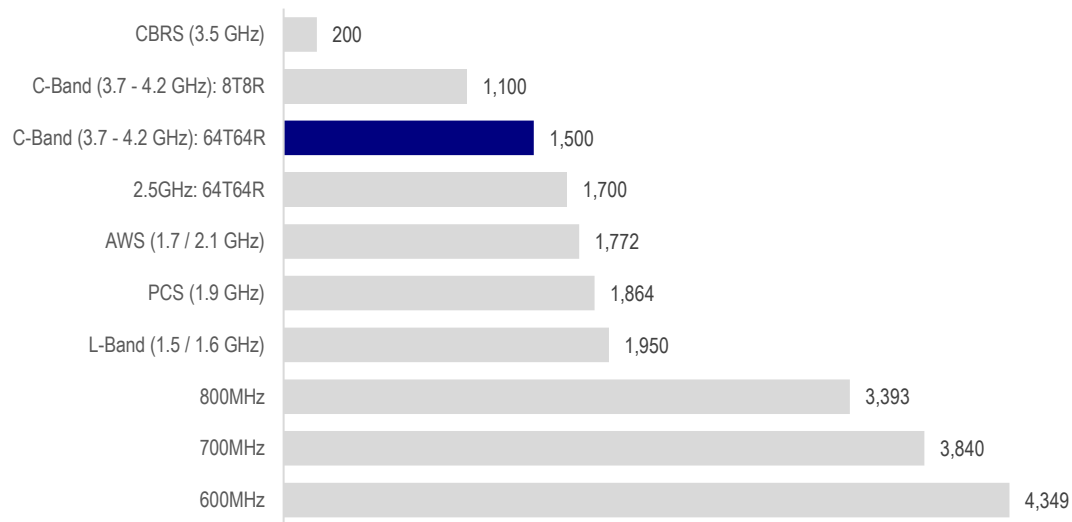
CBRS Auction Proceeds
\$, millions



Source: Company data, New Street Research estimates

Step #2: The Reach Of Upper Mid-Band Spectrum

Typical Cell Radius By Band¹ Meters

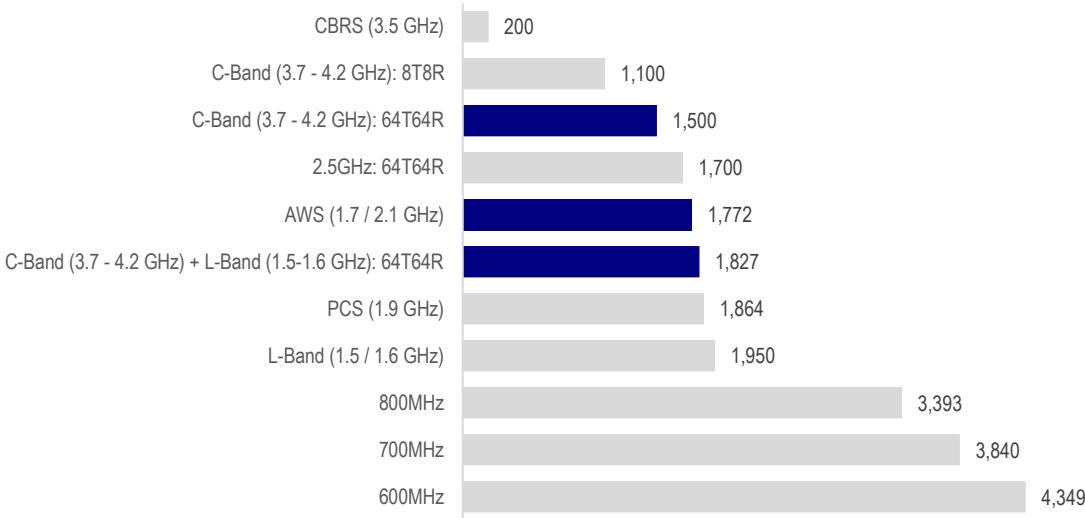


Controversy #4: The impact of massive MIMO and beamforming on reach

¹ C-Band with 64T64R assumes improvement in range from massive MIMO; without this, range would be 1,100 meters (as shown with 8T8R)
Source: Company data, New Street Research estimates

Step #3: Quantifying The Improvement In Reach With SUL

Typical Cell Radius By Band¹ *Meters*



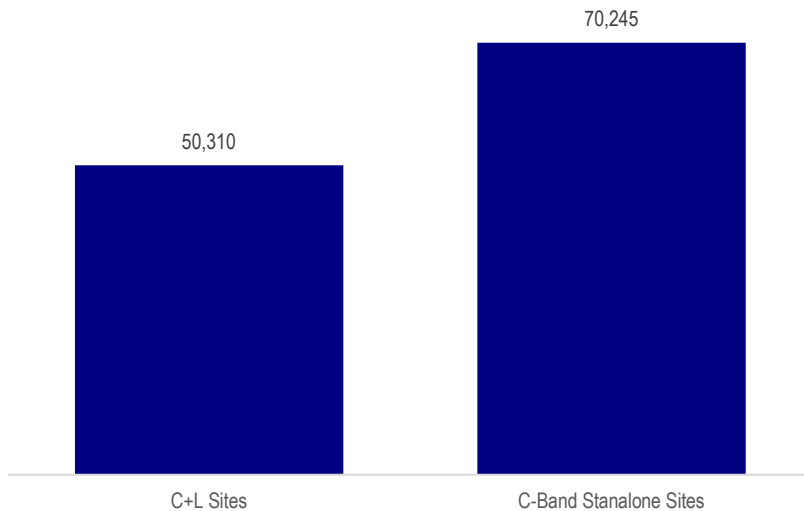
¹ C-Band with 64T64R assumes improvement in range from massive MIMO; without this, range would be 1,100 meters (as shown with 8T8R)
Source: Company data, New Street Research estimates

Step #4: Valuing The Improvement In Reach With SUL

Avoided C-Band Sites With C+L

Macro sites

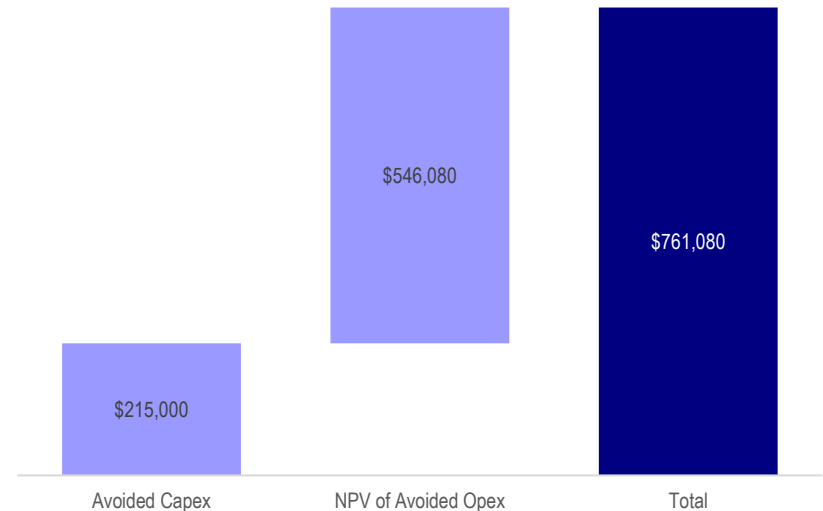
C+L results in 20K fewer macro sites than C-Band standalone



Savings Per Site

\$

20k avoided sites at a total cost of \$761K per site drive savings of \$15BN



Source: Company data, New Street Research estimates

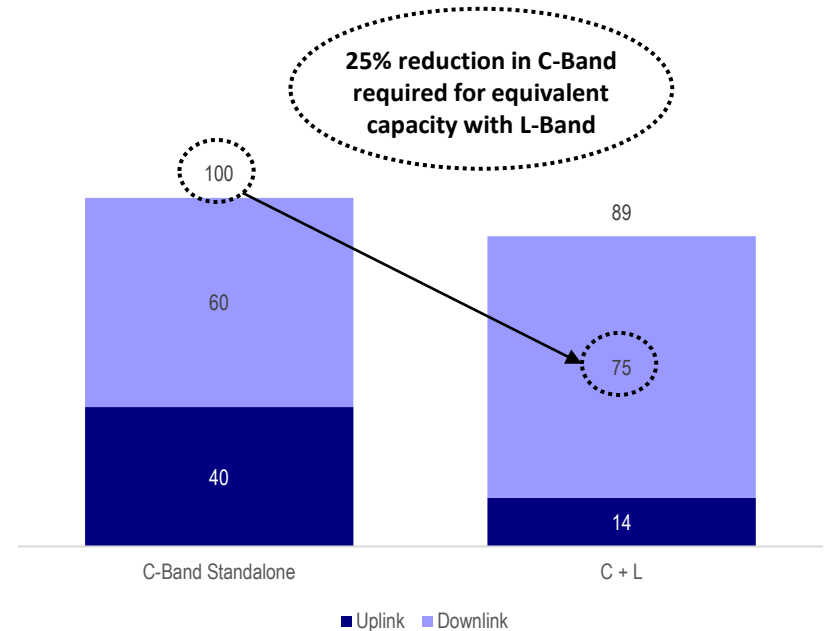
Step #5: Quantifying The Improvement In Capacity With SUL

C+L Capacity Enhancement

Config 5 has 8 downlink subframes – a 25% increase over Config 3 with 6

Uplink-Downlink Configuration	Uplink-to-Downlink Switch-Point Periodicity	Subframe Number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Capacity Equivalency: C+L vs. Standalone C-Band MHz

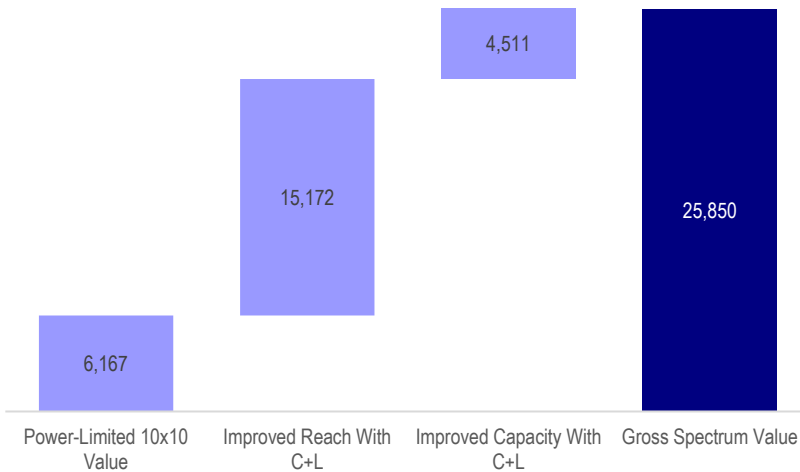


Controversy #5: Capacity improvement from supplemental uplink remains uncertain

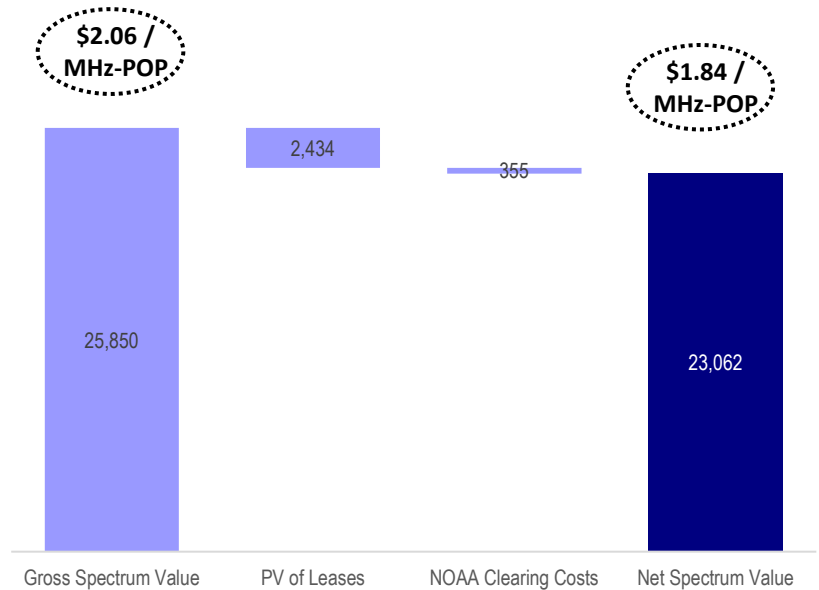
Source: Company data, New Street Research estimates

Step #6: Tying It All Together

Value of L-Band With C+L Configuration
\$, millions



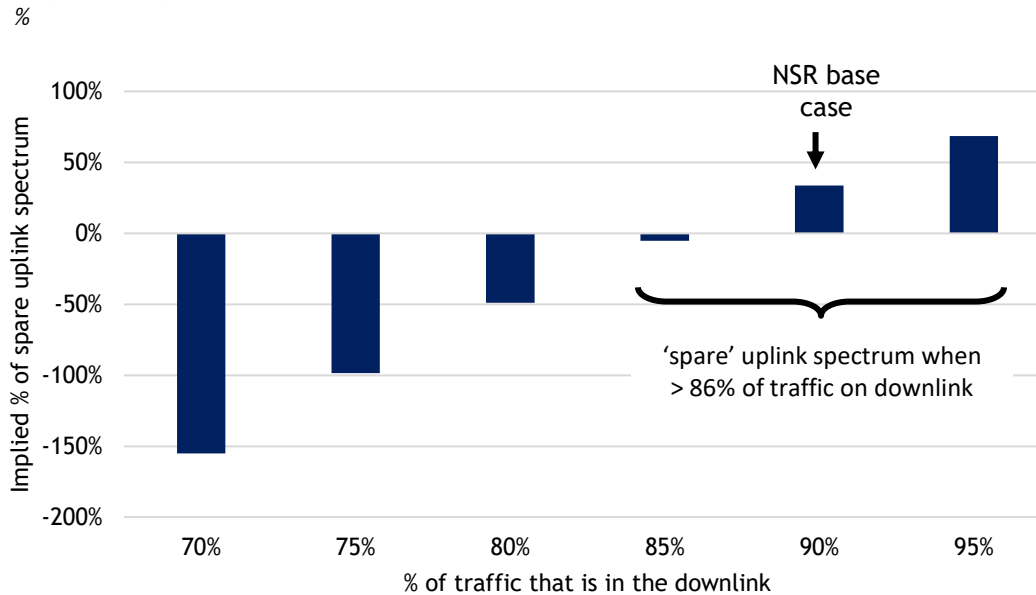
Ligado Value With C+L Configuration
\$, millions



¹ According to Debtwire, the lease terms with Inmarsat were amended in July 2020. On our estimates, the NPV of the amended lease would be \$1.0BN, down from \$2.3BN under the prior terms. We use the prior terms for valuation purposes because the amended lease terms have not been publicly disclosed and they are contingent on financial payouts; however, this is likely conservative;

Key Controversy: Carriers May Have Alternatives

Typical Uplink Utilization Sensitized To Traffic Asymmetry

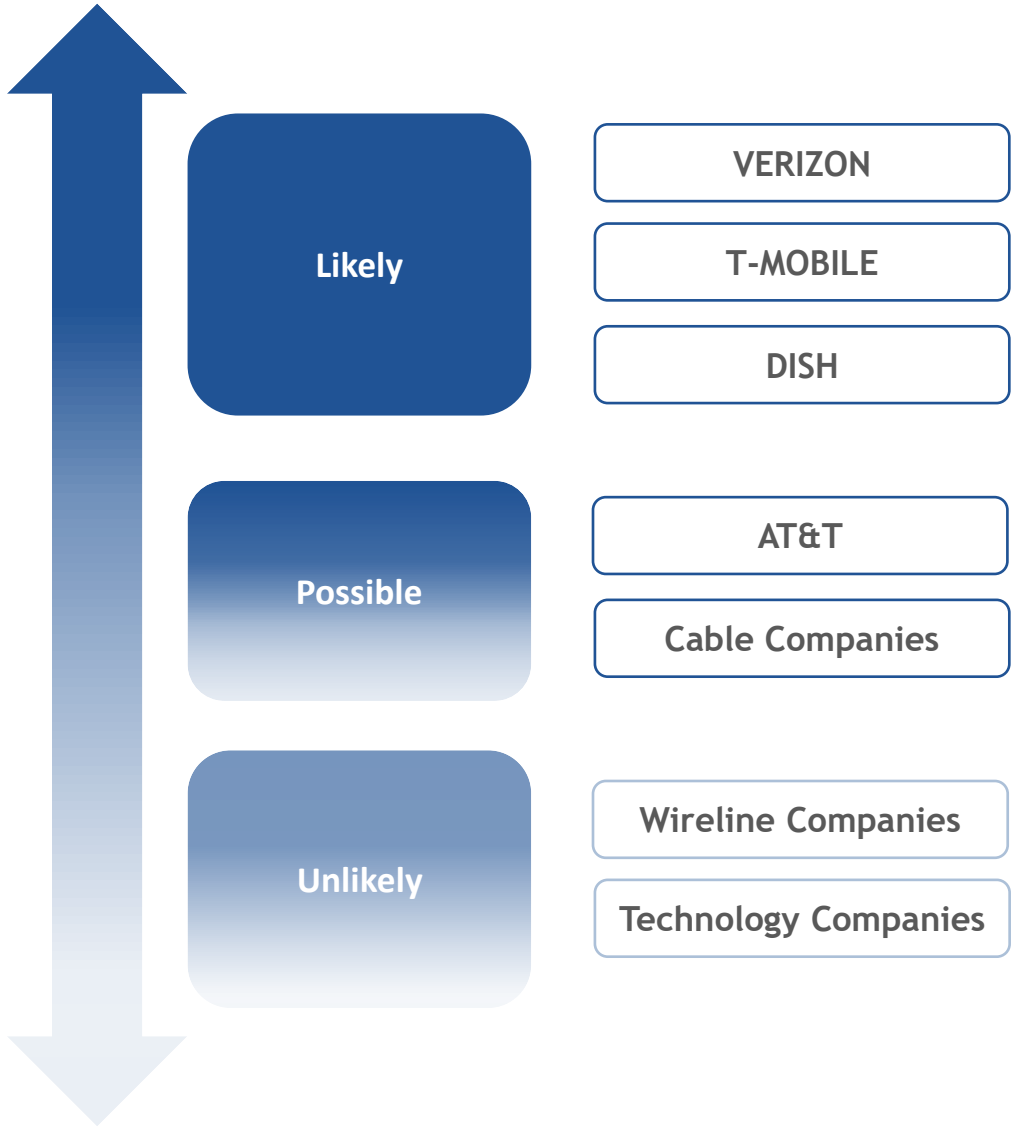


Controversy #6: Carriers may have enough supplemental uplink among existing bands

Source: Company data, New Street Research estimates

Valuing & Strategic Fit By Carrier

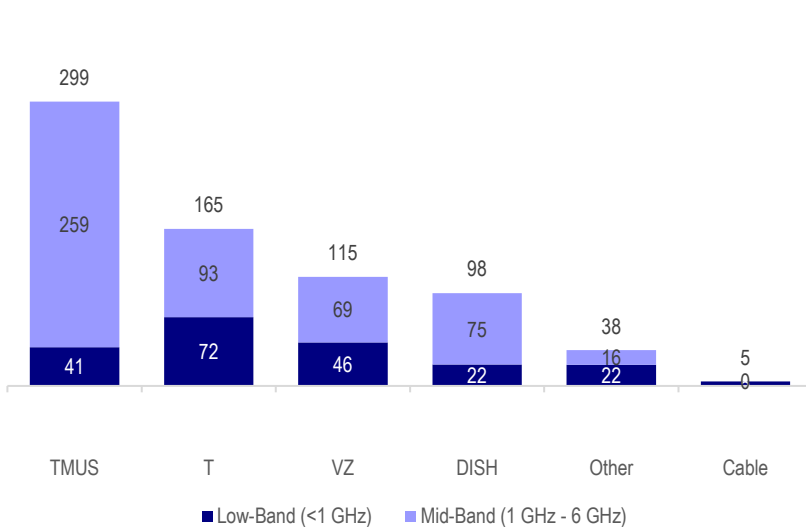
Potential Bidders



All Carriers Should Value More Capacity; Some Need it More Than Others

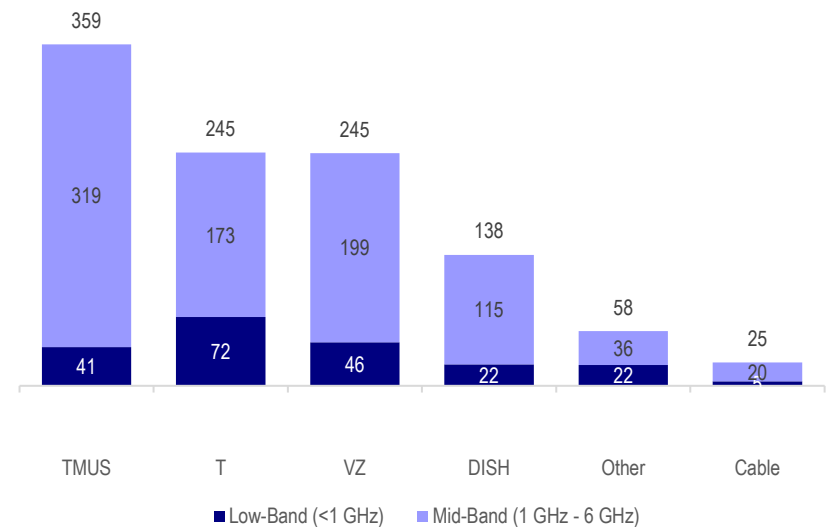
Spectrum Holdings Below 6GHz By Carrier

MHz, national average



Spectrum Holdings Below 6GHz By Carrier: Pro-Forma For C-Band

MHz, national average

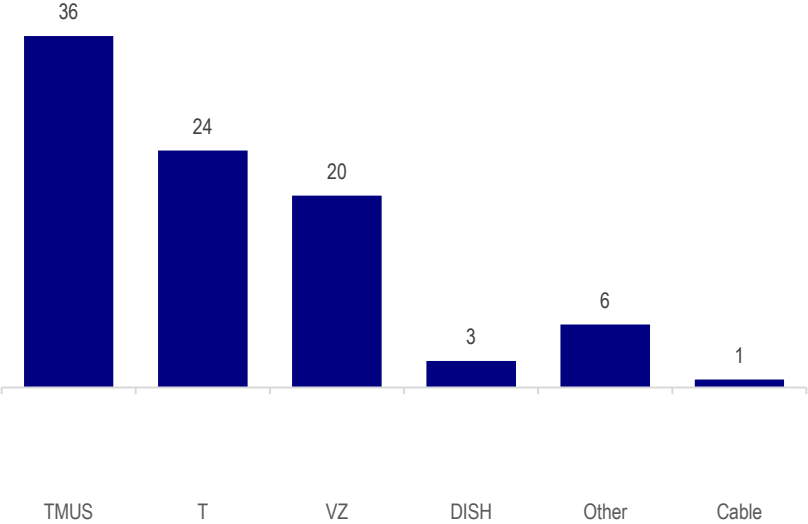


Controversy #7: Is there more than one bidder

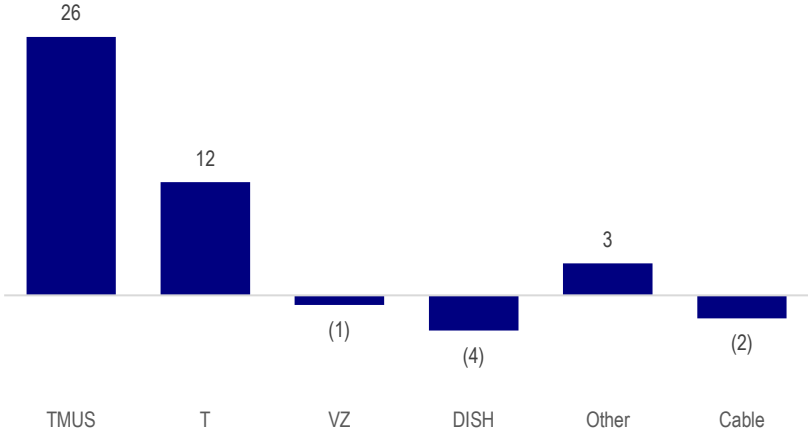
Source: Company data, New Street Research estimates

Supplemental Uplink Use Case Could Confer Decisive Advantage

Excess Uplink Spectrum Holdings By Carrier
MHz



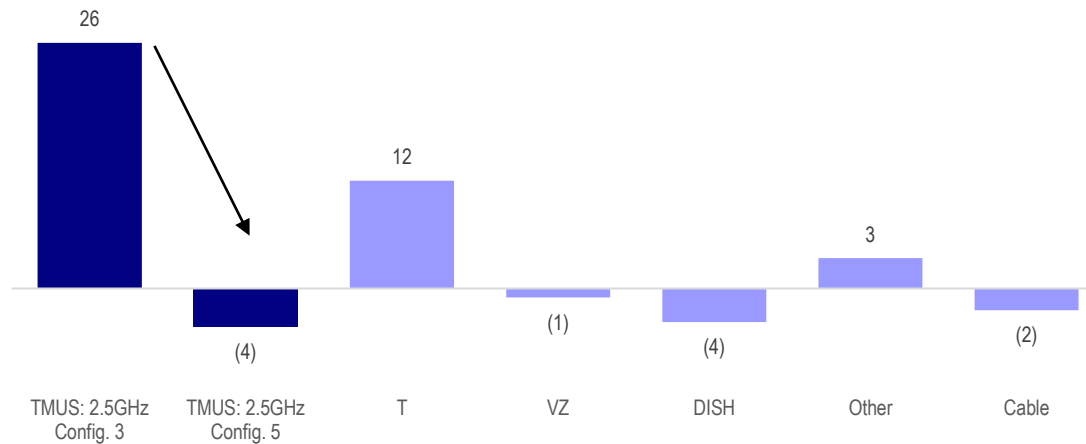
Excess Uplink Spectrum Holdings By Carrier: Pro-Forma For C-Band¹
MHz



¹ Assumes utilization of C-Band configuration 5 (maximum time slots allotted to downlink)
Source: Company data, New Street Research estimates

T-Mobile's Spectrum Position May Drive Greater Demand

Excess Uplink Spectrum Holdings By Carrier: Pro-Forma For C-Band¹
MHz



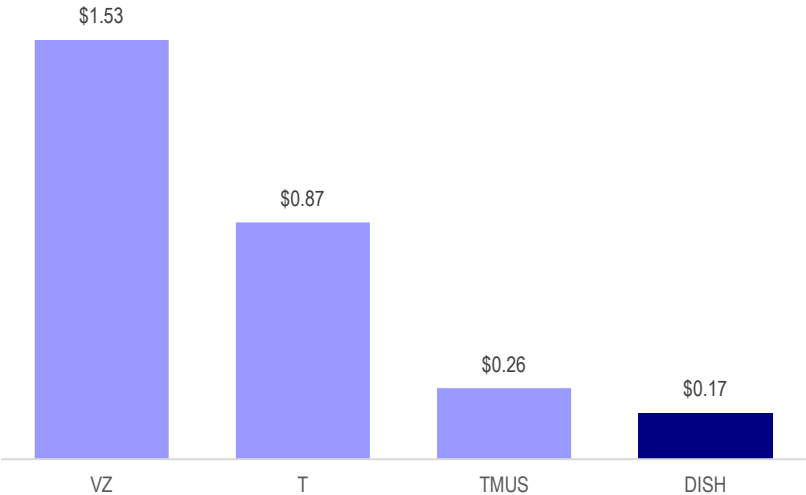
¹ Assumes utilization of C-Band configuration 5 (maximum time slots allotted to downlink)

Source: Company data, New Street Research estimates

Dish Needs To Preserve Cost Advantage

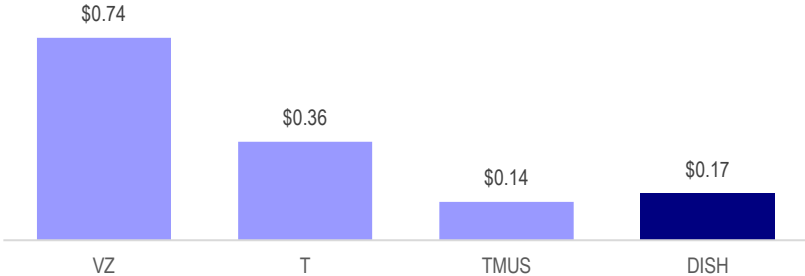
Network Cost Per GB at 100% Utilization¹

\$/GB, 2020



Network Cost Per GB at 100% Utilization

\$/GB, 2029



¹ DISH pro-forma for network build; assumes 2029
Source: Company data, New Street Research estimates

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Ratings History

Full 12-month historical recommendation changes are available on request

Disclosure:

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12 month historical recommendation changes are available on request

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