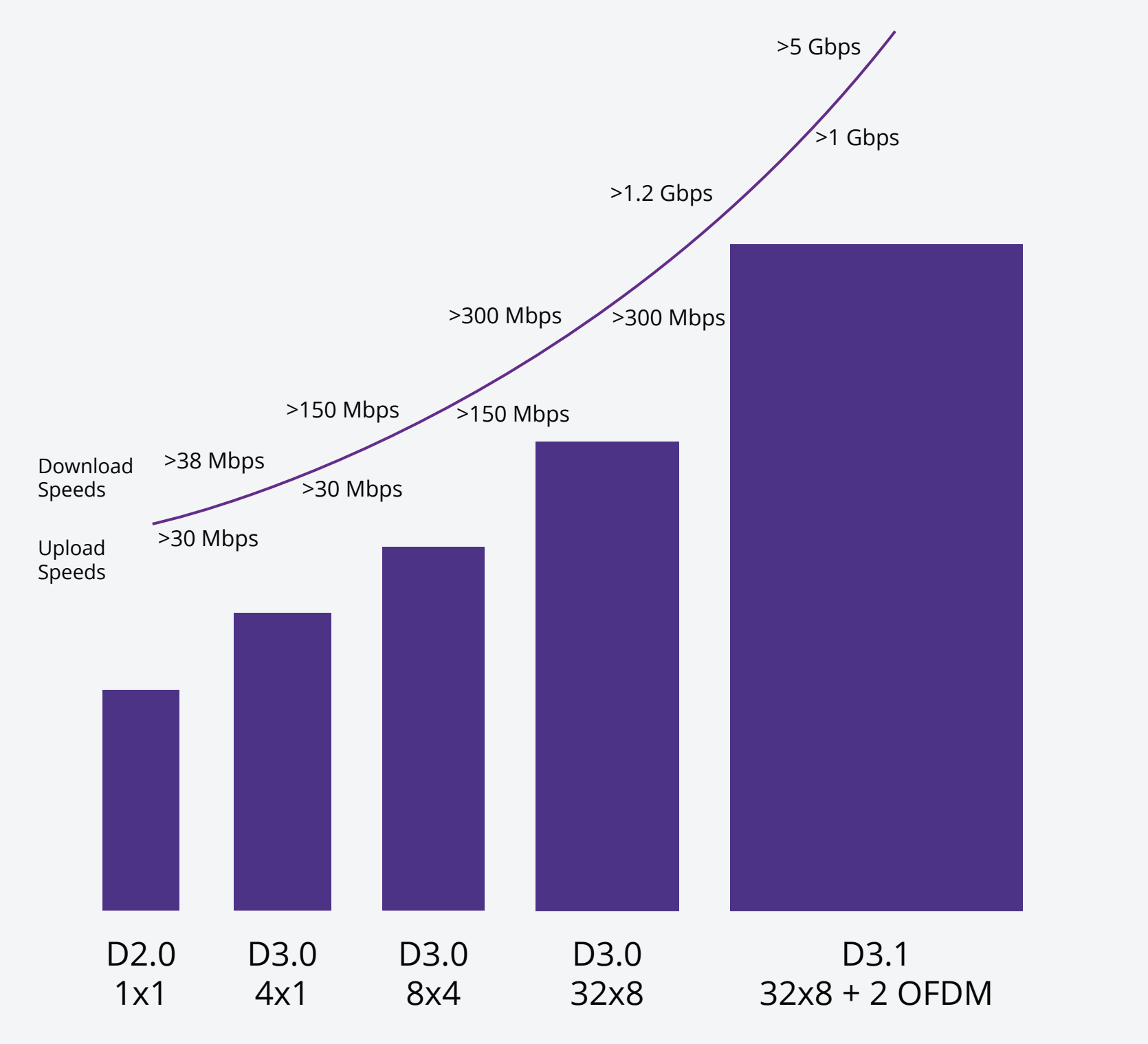
PUTTING DOCSIS 3.1 NETWORKS TO THE TEST

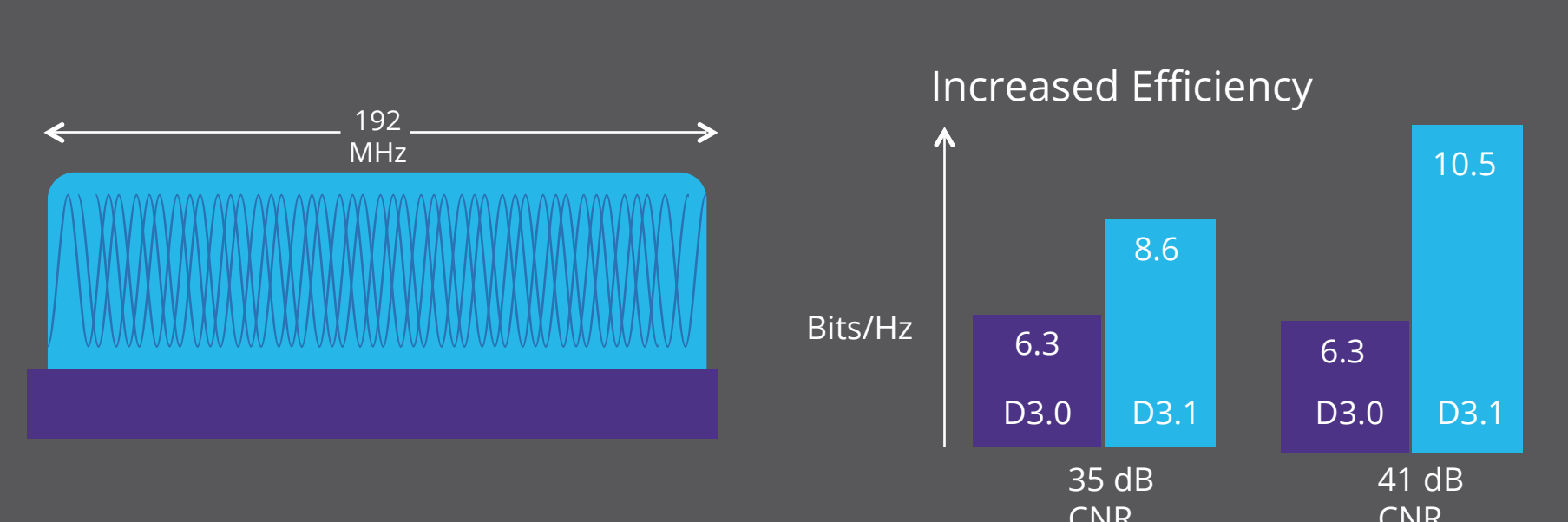
With DOCSIS 3.1, cable companies will be able to make an enormous leap in broadband transmission rates. D3.1 includes new technologies, and its implementation can be complex. Preparing the network and monitoring its performance will be critical.

Channel Bonding Pushes the Speed Limit



DOCSIS 3.1 adds support for bonding 32 QAM carriers plus 2 OFDM carriers on the downstream, and 8 QAM carriers plus 2 OFDM carriers on the upstream. Proper bonding needs to be verified to assure customers receive their expected service level by performing a DOCSIS 3.1 range and registration test. Proper bonding of DOCSIS 3.0 and 3.1 carriers also must be verified.

OFDM Changes the Game

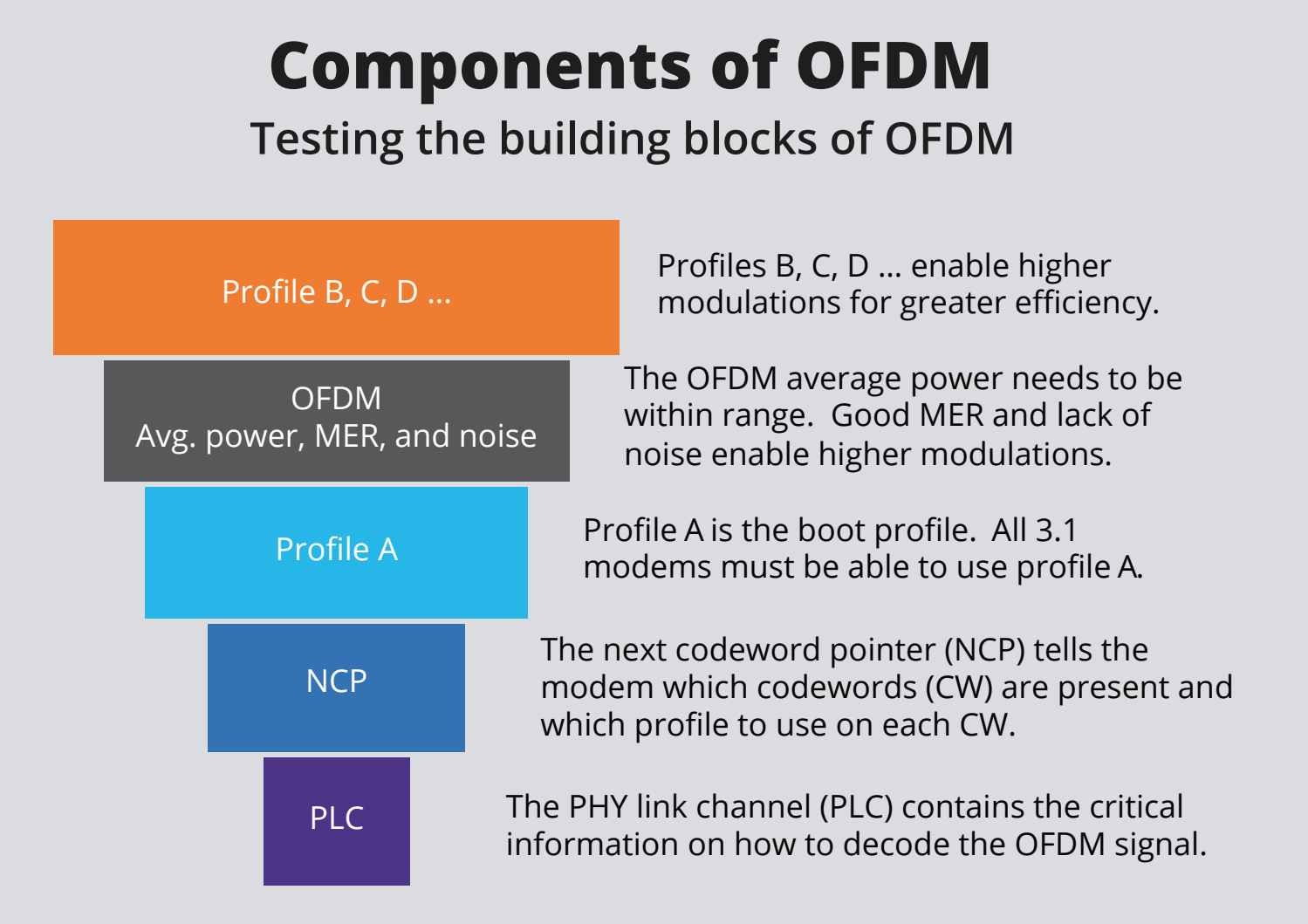


6.3	*Max bits/Hz DOCSIS 3.0*
10.5	*Max bits/Hz D3.1 4096 QAM*
8.5	*Typical bits/Hz DOCSIS 3.1* *(assumes mix of 256,1024, 2048, 4096 QAM)*
35%	*More Efficient* DOCSIS 3.1 bits/Hz than DOCSIS 3.0

Orthogonal frequency domain multiplexing departs from having a single QAM carrier in 6 MHz to using 4k or 8k overlapping subcarriers across 24-192 MHz. OFDM provides more bits/Hz at the same signal-to-noise operating conditions. The added complexity provides additional efficiency and noise immunity to the cable system.

Components of OFDM

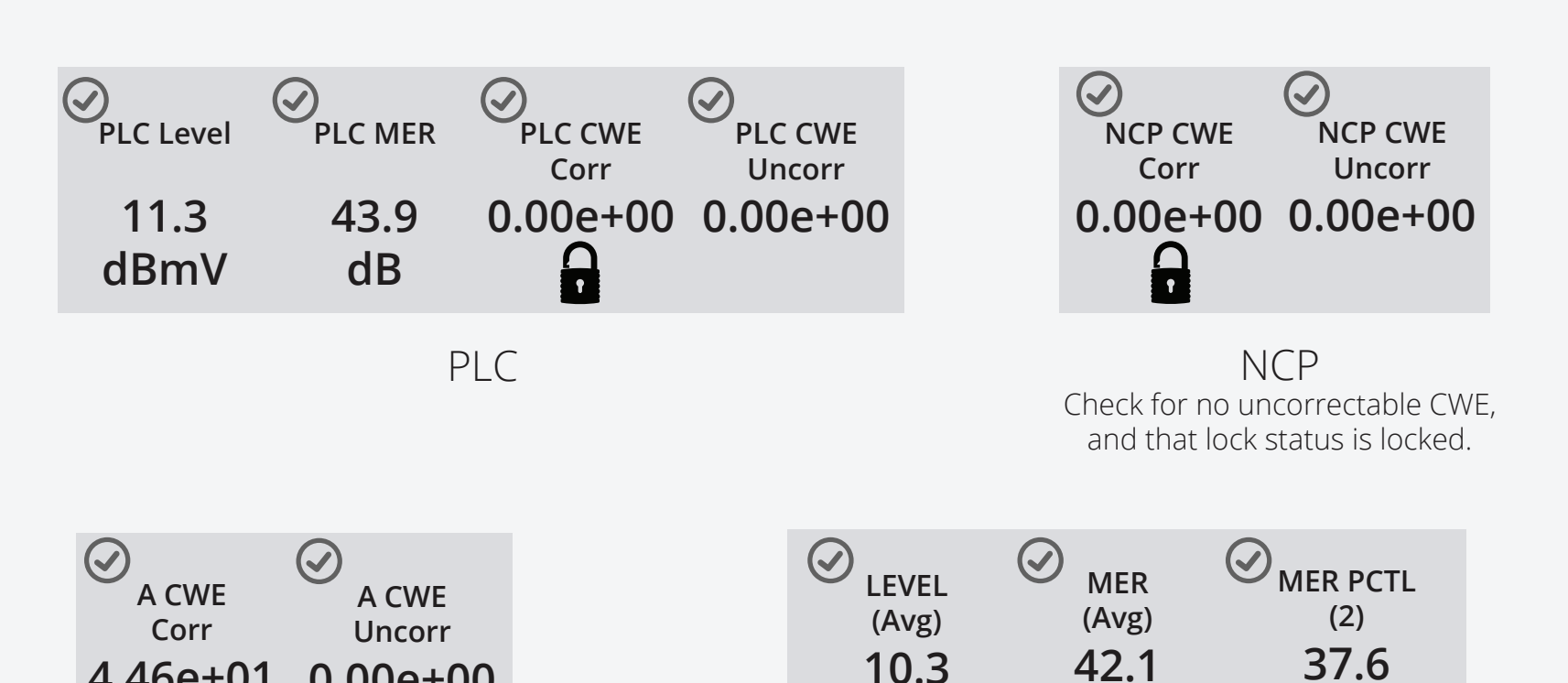
Testing the building blocks of OFDM



There are multiple OFDM components. An effective test routine will assure the proper functioning of a DOCSIS 3.1 network.

Checklist

Look for NO uncorrectable codeword errors (CWE) for the PLC, NCP and Profile A. Make sure that the PLC, NCP, and Profile A are locked on.



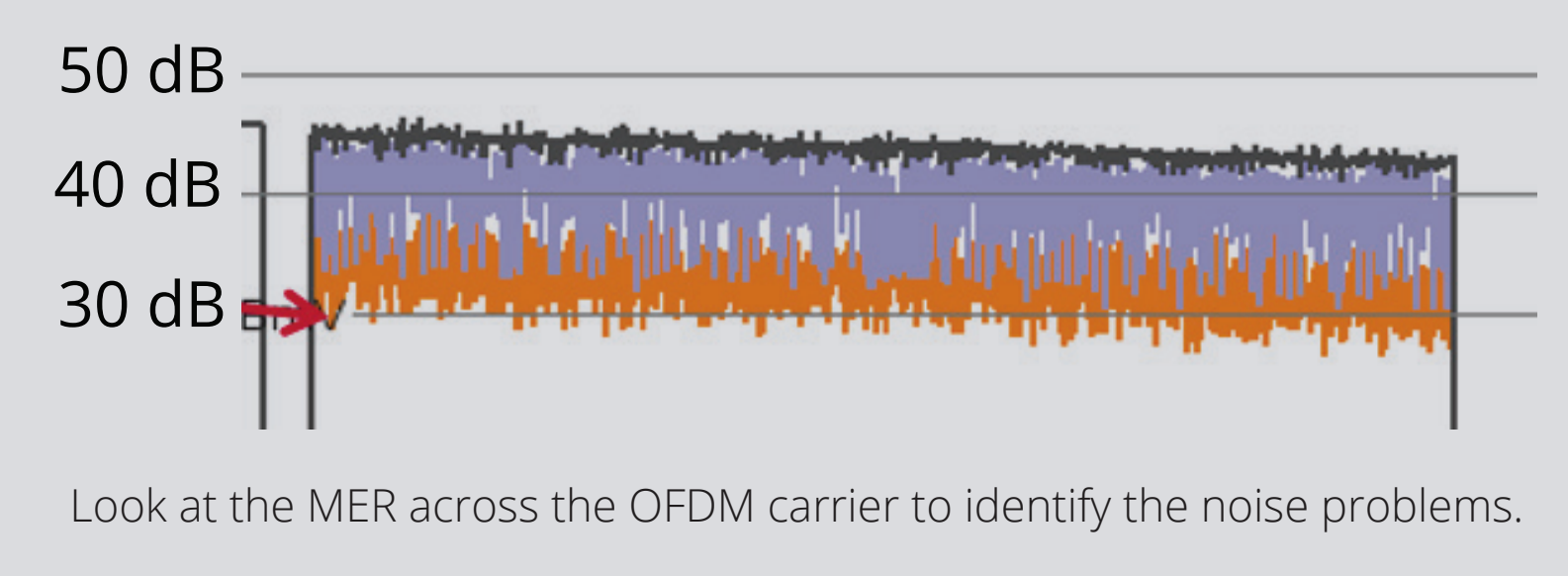
Looking at the 2nd percentile shows how good 98% of the subcarriers are working and weeds out a couple underperforming ones since LDPC error correction will likely clear it up. If profile A isn't locked or has uncorrectable CWE, the modem may roll back and use only SC-QAMs in 3.0 mode. Among the things to check: Avg LEVEL: variable, >-6 dBmV recommended; Avg level: variable, >-6 dBmV recommended; Avg MER: variable, >36 dB recommended; MER @2nd percentile: >35 dB recommended.

The HFC Plant

Min CNR/MER dB	Channel Modulation	MinAvg Power (6 MHz) dBmV
41	*4096 QAM OFDM*	-6
37	*2048 QAM OFDM*	-9
34	*1024 QAM OFDM*	-12
27	*256 QAM OFDM*	-15
15	*16 QAM OFDM*	-15

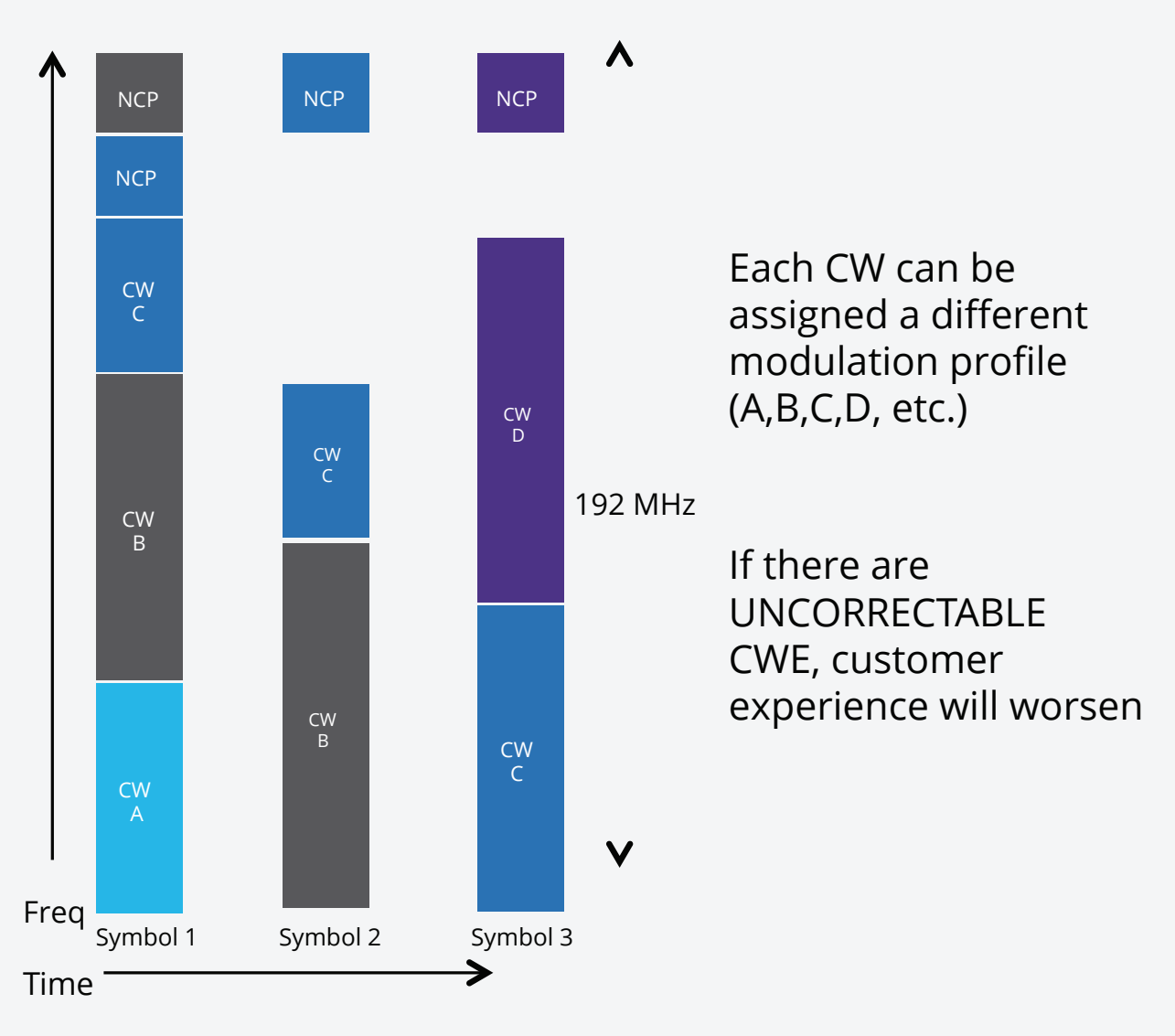
A clean HFC plant is required to run higher modulations.

MER/CNR Across OFDM Carrier



Look at the MER across the OFDM carrier to identify the noise problems.

Error Correction



DOCSIS 3.1 will retire Reed-Solomon forward error correction and adopt low density parity check (LDPC) error correction. With OFDM and LDPC, the data will be carried on multiple frequencies with multiple modulation types that vary from symbol to symbol in groups (CW). CWE are the new metric, instead of BER.

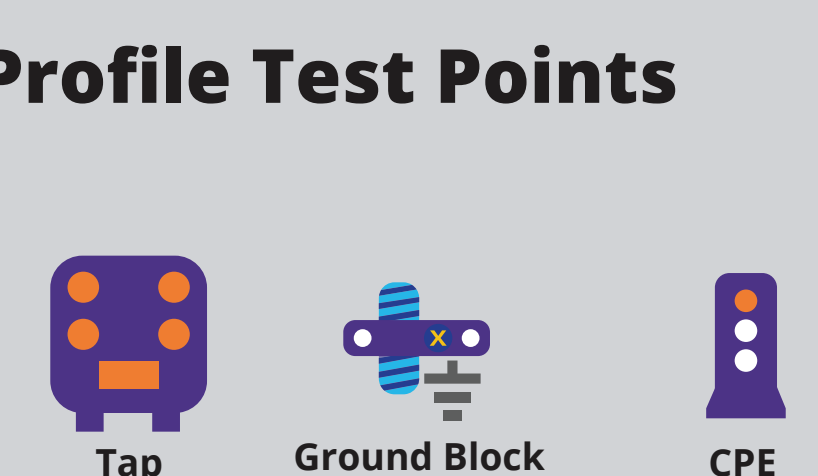
Higher Profile Performance

Profile B, C, D ...

Profile	Locked?	CWE Correctable	CWE
A	YES		0.0e+00
B	YES	2.0e-01	0.0e+00
C	YES	01.6e-09	1.7e-05
D	NO	N/A	N/A

Correctable CWE are expected on higher profiles. Need to balance uncorrectable CWE versus retries.

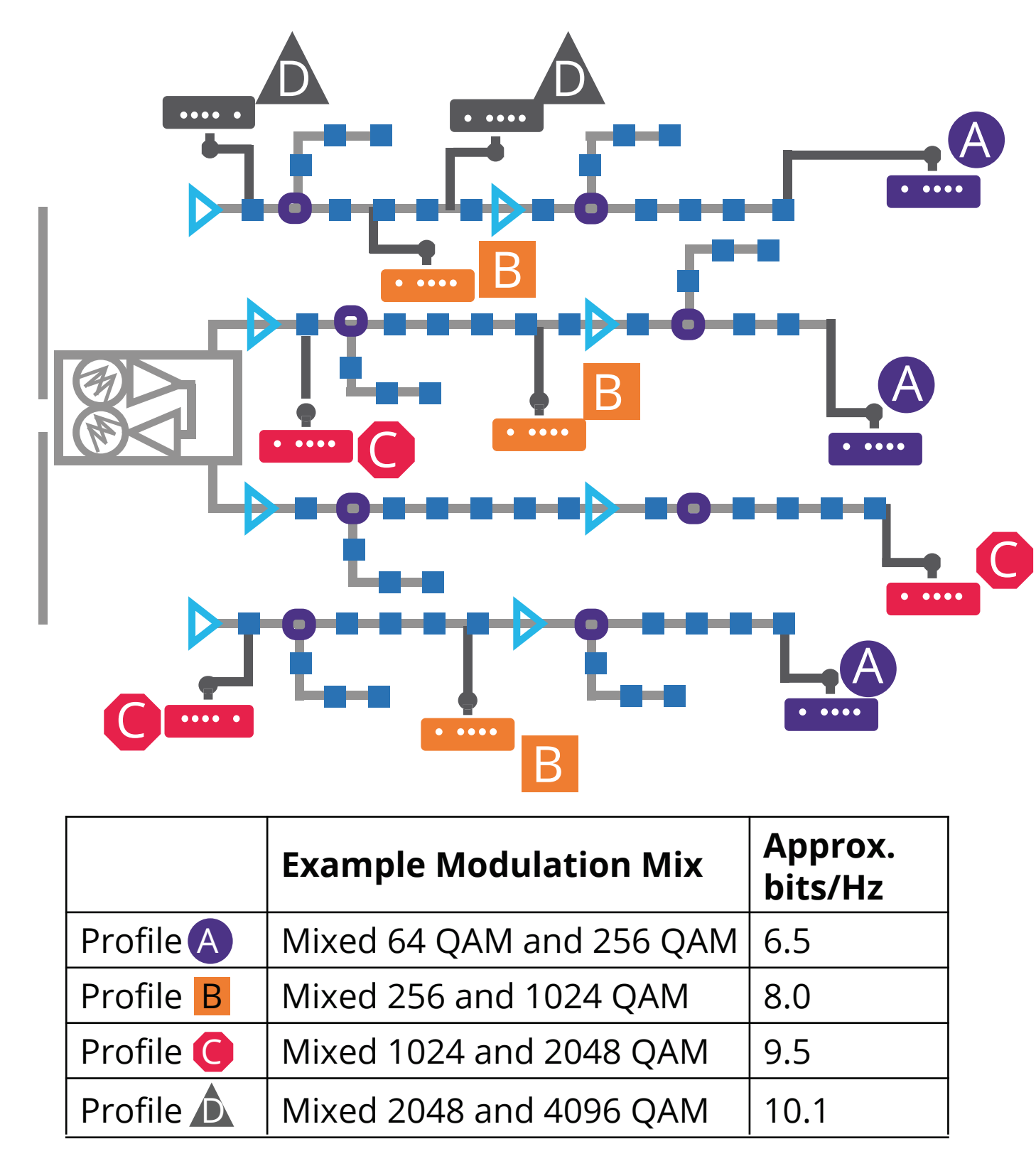
Profile Test Points



	Tap		Ground Block		Outlet	
	Profile Locked?	Uncorrectable CWE	Profile Locked?	Uncorrectable CWE	Profile Locked?	Uncorrectable CWE
Profile A	YES	NO	YES	NO	YES	NO
Profile B	YES	NO	YES	NO	NO	YES
Profile C	YES	NO	YES	YES	NO	YES
Profile D	YES	NO	NO	YES	NO	YES

Profile changes highlight problems in drop and/or home wiring. Using a test device that looks at profiles can identify problems in the drop and wiring.

Mixing Modem Profiles

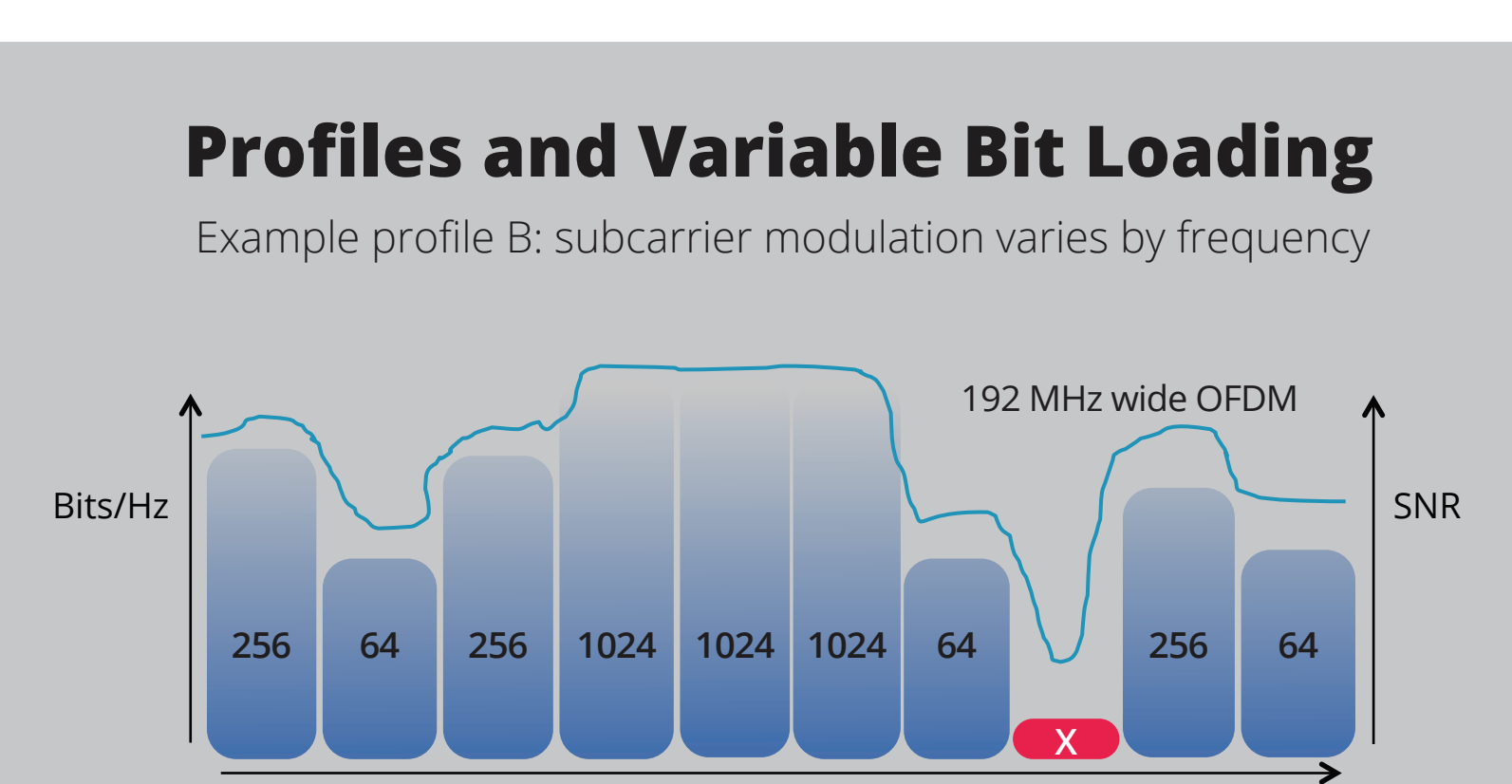


	Example Modulation Mix	Approx. bits/Hz
Profile A	Mixed 64 QAM and 256 QAM	6.5
Profile B	Mixed 256 and 1024 QAM	8.0
Profile C	Mixed 1024 and 2048 QAM	9.5
Profile D	Mixed 2048 and 4096 QAM	10.1

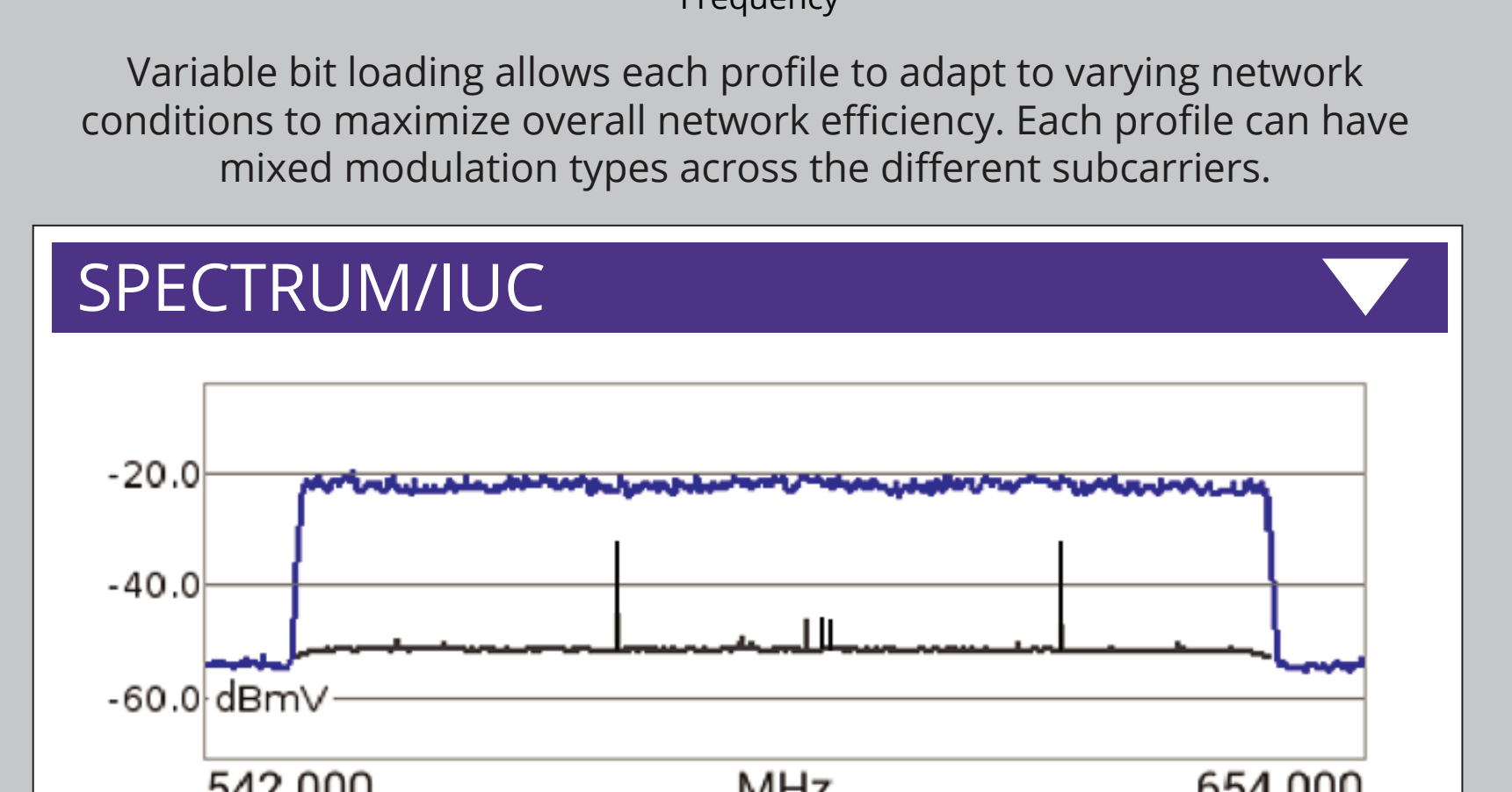
Profiles enable maximum speeds and maximize overall network capacity and throughput. Not all parts of the network will be able to operate on the highest profile, however, due to varying network conditions. Testing for different profiles can help improve plant performance and improve overall customer QOE.

Profiles and Variable Bit Loading

Example profile B: subcarrier modulation varies by frequency

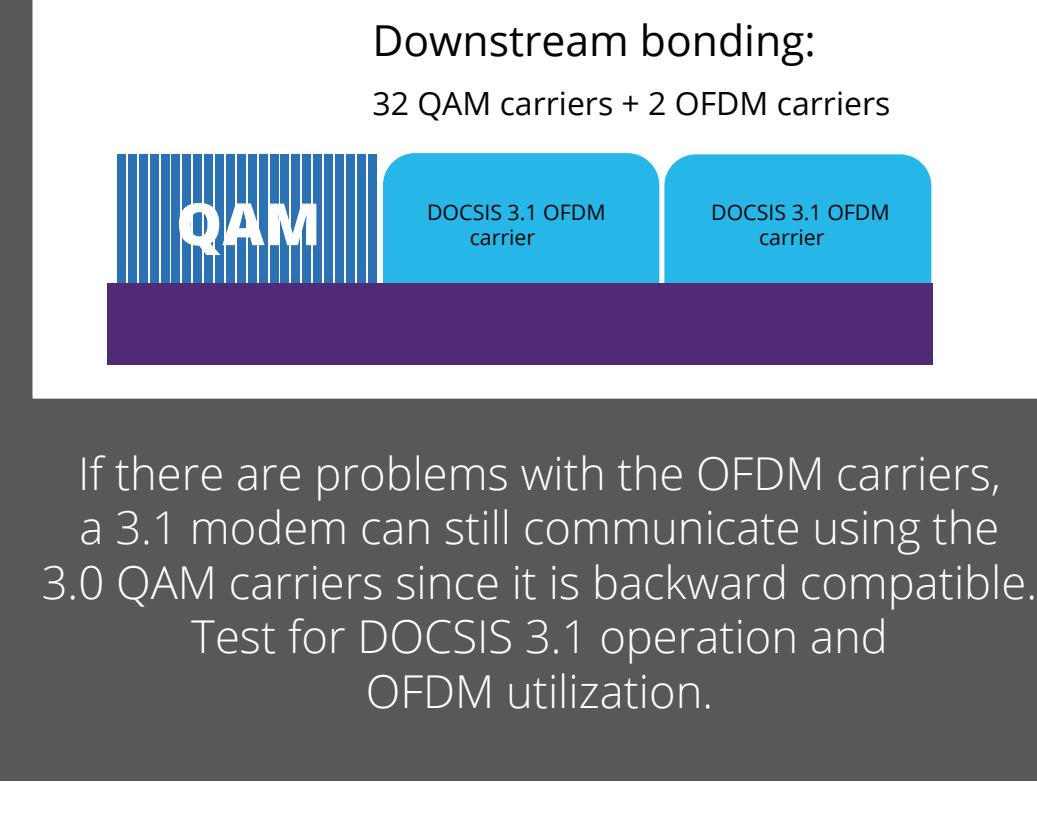


Variable bit loading allows each profile to adapt to varying network conditions to maximize overall network efficiency. Each profile can have mixed modulation types across the different subcarriers.



Identifying noise sources under the OFDM carrier can help plan for frequency exclusions or modulation changes for the subcarriers.

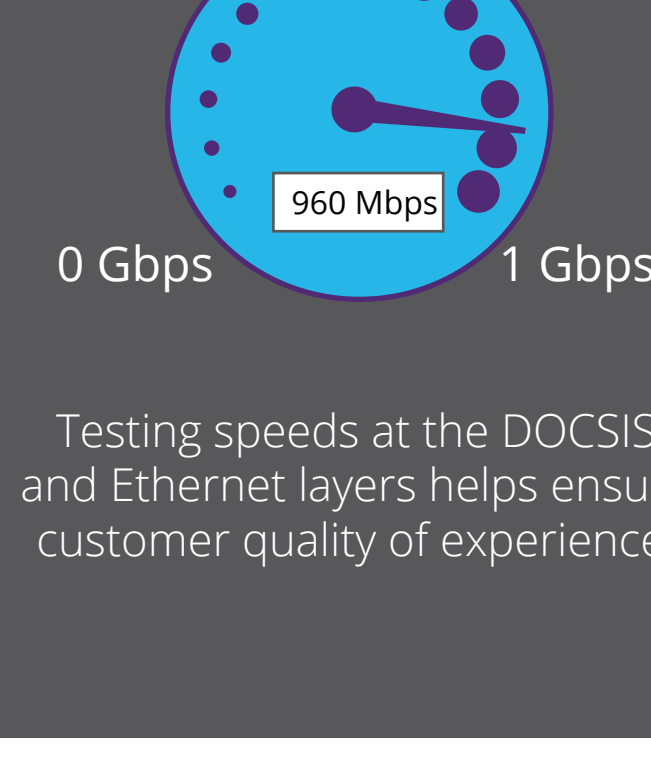
Service Level Testing



If there are problems with the OFDM carriers, a 3.1 modem can still communicate using the 3.0 QAM carriers since it is backward compatible. Test for DOCSIS 3.1 operation and OFDM utilization.

Throughput and Bandwidth

Download Speeds



Testing speeds at the DOCSIS and Ethernet layers helps ensure customer quality of experience.

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