

TR-398 Issue 4 WiFi Testing with LANforge: 32 WiFi-7 Radios + Mesh

The TR-398 WiFi Performance test plan by the Broadband forum provides a comprehensive set of tests to qualify the performance of WiFi access points (APs) to be deployed in residential and small office indoor environments. The TR-398 Issue 4 will include TR-398 Issue 3 features as well as WiFi-7 support. The Candela TR398 test cases allows customization of test execution and pass/fail metrics to allow interested users to run advanced tests not specified in TR398.

The TR398 issue-3 document from Broadband Forum is still in progress. Pass/fail thresholds and perhaps some other small changes to the test procedure are still being resolved.

See example reports auto-generated by this testbed:

- 6.1.1 RX Sensitivity at different angles and encodings.
- 6.2.1 Max Connection 32 station throughput
- 6.2.2 Max TCP Throughput
- 6.2.3 Airtime Fairness
- 6.2.4 Dual Band Throughput
- 6.2.5 TCP Bi-directional Throughput
- 6.2.6 Latency under Load Test
- 6.2.7 Quality of Service
- 6.2.8 Multi-Band Throughput
- 6.3.1 Rate vs Range
- 6.3.2 Spatial Consistency
- 6.3.3 Peak Performance
- 6.4.1 Multiple Stations Performance
- 6.4.2 Multiple Association Stability
- 6.4.3 Downlink MU-MIMO, Requires that AP must be able to disable/enable MU-MIMO.
- 6.4.4 Multicast Multi-Station
- 6.5.1 Long Term Stability.
- 6.5.2 AP Coexistence
- 6.5.3 Automatic channel selection.
- 6.6.1 Mesh Backhaul Rate vs Range
- 6.6.2 2-hop Mesh Backhaul Rate vs Range
- 6.6.3 Mesh Roam



Test Setup Information	
Name	TR-398
Device Under Test	ASUS RT-AX88U
SSID	ASUS-RT-AX88U
SSID2	ASUS-RT-AX88U-2
SSID3	ASUS-RT-AX88U-3
SSID4	ASUS-RT-AX88U-4
SSID5	ASUS-RT-AX88U-5
SSID6	ASUS-RT-AX88U-6
SSID7	ASUS-RT-AX88U-7
SSID8	ASUS-RT-AX88U-8
SSID9	ASUS-RT-AX88U-9
SSID10	ASUS-RT-AX88U-10
Estimated Run Time	17.5h
Actual Run Time	18:01 h

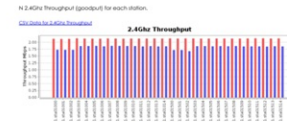
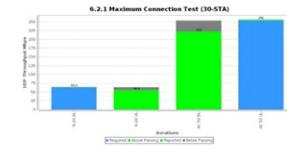
Objective

The TR-398 Issue 3 WiFi Performance Test Plan by the Broadband Forum provides a comprehensive set of tests to verify the performance of WiFi stations (WLAN) designed for residential and small office environments. Radio performance, throughput, connection stability, antenna fairness, AP Co-existence, MU-MIMO Performance, Spatial Consistency and Long-term Stability are some of the key tests covered in this test plan. The test plan is designed for service providers (residing in home WiFi APs) to verify the APs in their field deployment and for equipment makers to test during the development of APs. Candela Technologies offers a fully automated TR-398 Issue 3 test system. The user can select from the list of tests available, install each test on the testbed, though some require user interaction. Measurements are made and compared to the specified PASS/FAIL criteria in the TR-398 Issue 3 test plan and this report will show the summary PASS/FAIL results followed by more detailed results for each test.

Summary Results

Test	Result	Compass	Passed	Info
Capability Mesh Band Advertisement (BS to Node-1)	Pass	0	0	
Capability Mesh Band Advertisement (BS to Node-2)	Pass	0	0	
4.1.1 Receiver Sensitivity Test	Pass	41	2000 h	N: 2.4GHz Passed 2 / 2 (Min Rx Avg: 10.1 N Pass Avg: 13.0) N: 5GHz Passed 0 (Min Rx Avg: 14.0) N: 6GHz Passed 0 (Min Rx Avg: 14.0) N: 4GHz Passed 14 / 14 (Pass Avg: 4.2) N: 5GHz Failed by 0.0 N: 6GHz Failed by 0.0 Passed by 0.0 Mbps Internal ERROR: Retention table failed to create.
4.2.1 Maximum Connection Test (30-STA)	Pass	83	13:18h	Throughput: N: 2.4GHz: 18.64 (18.0), 101.02% Throughput: AC: 5GHz: 151.02%

ETA	Test	Result	Compass	Passed	Info
	4.2.2 Maximum TCP Throughput Test	Pass	92	8:56h	Throughput: N: 2.4GHz: 18.1 (18.0), 101.11% Throughput: AC: 5GHz: 18.64 (18.0), 103.56% Throughput: AC: 6GHz: 18.64 (18.0), 103.56%
	4.2.3 Airtime Fairness Test	Pass	0	32:30h	AC: 5GHz Passed 0 / 4 N: 2.4GHz Passed 3 / 6
	4.2.3 Issue 3 Airtime Fairness Test	Pass	0	0	
	4.4.4 Multiple STA Multicast Test	Pass	0	0	
	4.2.4 Dual-Band Throughput Test	Pass	45	28:21h	N: 7 / 12 AC: 4 / 12
	4.2.5 Bidirectional UDP Throughput Test	Pass	50	34:45h	N: 2.4GHz Passed 1 / 3 AC: 5GHz Passed 2 / 3
	4.2.6 Latency Test	Pass	0	0	
	4.2.7 Quality of Service Test	Pass	0	0	
	4.3.1 Range Versus Rate Test	Pass	38	2:12h	N: 2.4GHz: 16.5 / 17.0, 3 / 17 AC: 5GHz: 16.9 / 14.0, 8 / 14
	4.3.2 Spatial Consistency Test	Pass	0	58:04h	Internal ERROR: Retention table failed to create. N: 2.4GHz Passed 0 / 0 AC: 5GHz Passed 0 / 0 N: 2.4GHz Passed 0 / 0 AC: 5GHz Passed 0 / 0 N: 2.4GHz Passed 0 / 0 AC: 5GHz Passed 0 / 0
	4.3.3 AP Peak Performance TCP Throughput Test	Pass	0	0	
	4.4.1 Multiple STA Performance Test	Pass	53	29:17h	N: 2.4GHz Passed 4 / 6 AC: 5GHz Passed 0 / 6
	4.4.2 Multiple Association / Disassociation Stability Test	Pass	94	4:75h	N: 2.4GHz Passed 15 / 14 AC: 5GHz Passed 14 / 14
	4.4.3 Downlink MU-MIMO Performance Test	Pass	0	0	
	4.5.2 AP Coexistence Test	Pass	156	34:56h	Passed 4 / 8 NOTE: Auto-Coordinated Interferer Network Error: SG: 80MHz AC: 133.33 Mbps SG: 40MHz AC: 14.29 Mbps 2.4GHz 20MHz N: 23.40 Mbps
	4.5.3 Automatic Channel Selection	Pass	0	0	
	8.1.1 Mesh Backhaul BWR	Pass	0	0	
	8.1.2 Mesh Backhaul Node 2 BWR	Pass	0	0	
	8.1.3 Mesh Room Time	Pass	0	0	



Max Cx Test: Snapshot N: 2.4GHz Download

Test	Max	Min	Avg	Stdev	Pass	Fail	Info
4.2.1 Max Conn	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.2 TCP	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.3 Airtime	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.3 Issue 3	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.4 Dual-Band	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.5 UDP	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.6 Latency	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.2.7 QoS	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.3.1 Range	16.50	14.00	16.50	0.00	100%	0%	16.50 (14.0), 117.86%
4.3.2 Spatial	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.3.3 AP Peak	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.4.1 Multiple STA	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.4.2 Assoc/Disassoc	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.4.3 MU-MIMO	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.5.2 AP Coex	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
4.5.3 Auto Chan Sel	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
8.1.1 Mesh BWR	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
8.1.2 Mesh Node 2 BWR	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%
8.1.3 Mesh Room	18.64	18.00	18.64	0.00	100%	0%	18.64 (18.0), 103.56%

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Key Measurements

- PASS/FAIL results table for each test per the TR-398 document.
- Detailed per test measurements.

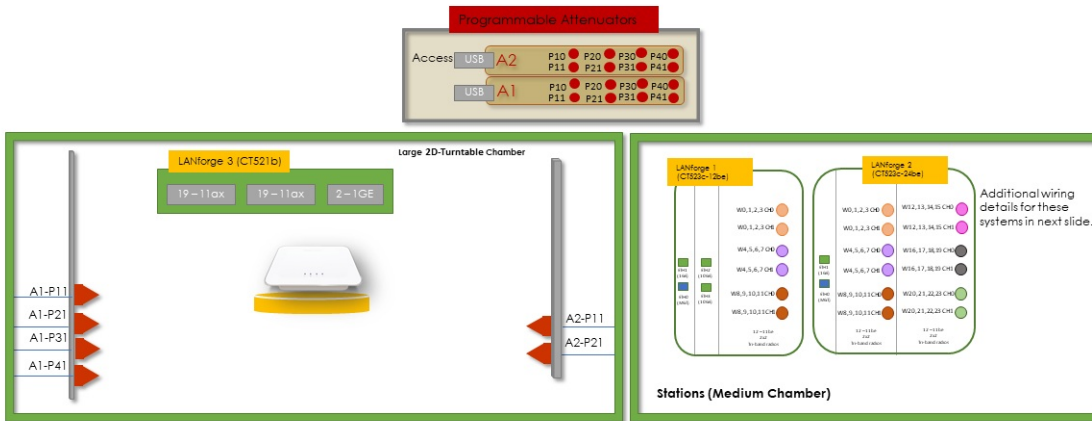
Overview

TR-398 Issue 3 Overview Video

Slide presentation for Candela Technologies' TR-398 issue 2 solution.

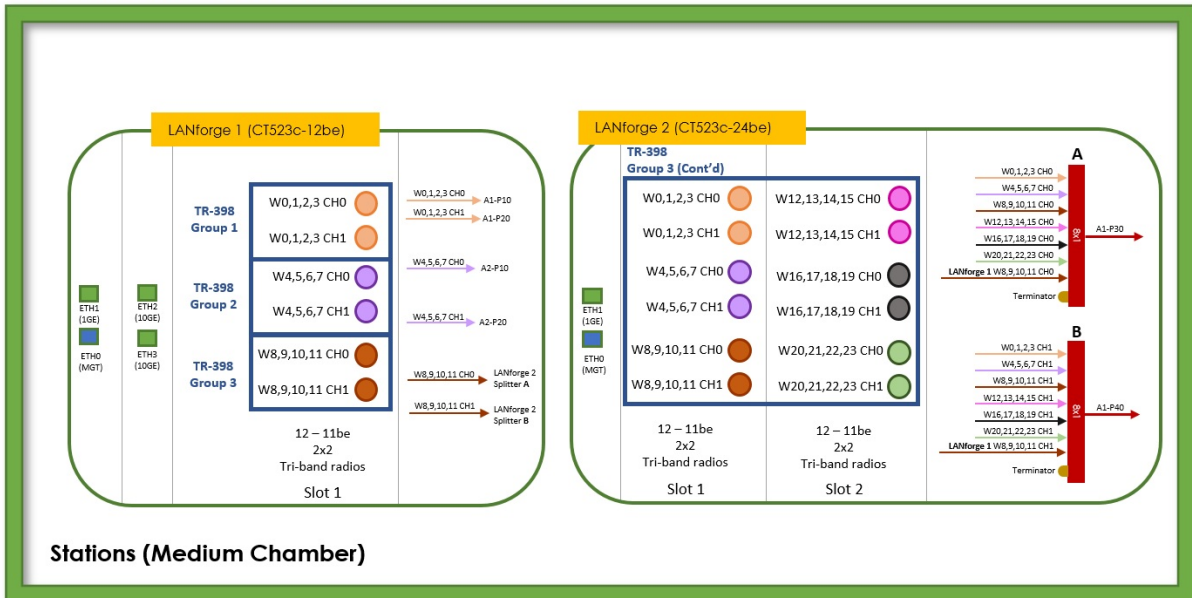
Candela Technologies offers a fully automated TR-398 Issue 4 test system. All the required test hardware including multi station emulator, traffic generator, RF enclosures, turntable, programmable attenuators, and fully automated test software along with PASS/FAIL results are provided in a packaged, easy to use and affordable solution. This testbed uses 32 Intel be200 tri-band WiFi-7 radios. These are not 'virtual' stations, so this testbed offers additional testing opportunities, including OFDMA, MU-MIMO and (in the future) MLO.

Wiring Diagram for TR398 Issue-4 without Mesh.

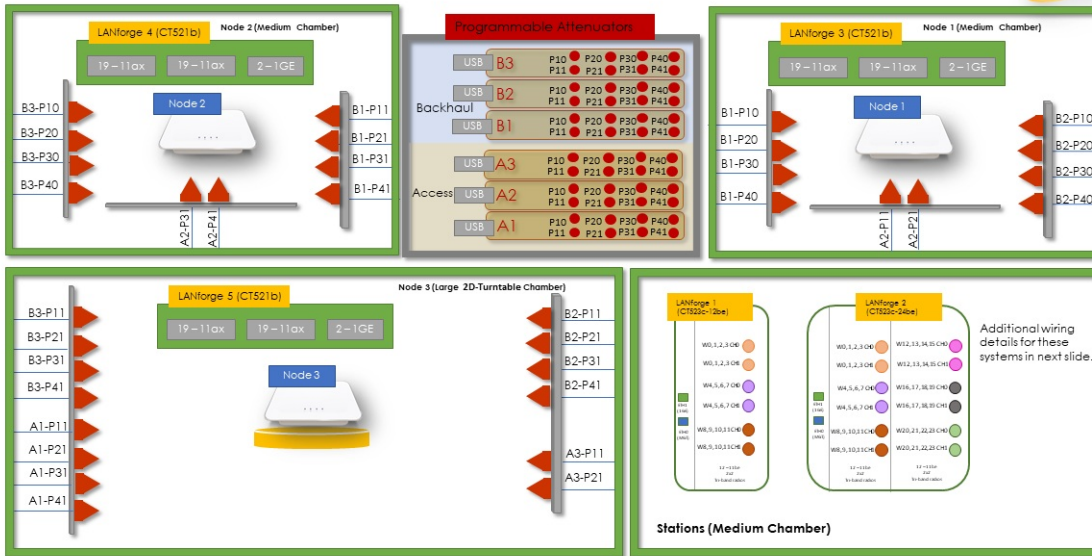


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Stations Chamber Details

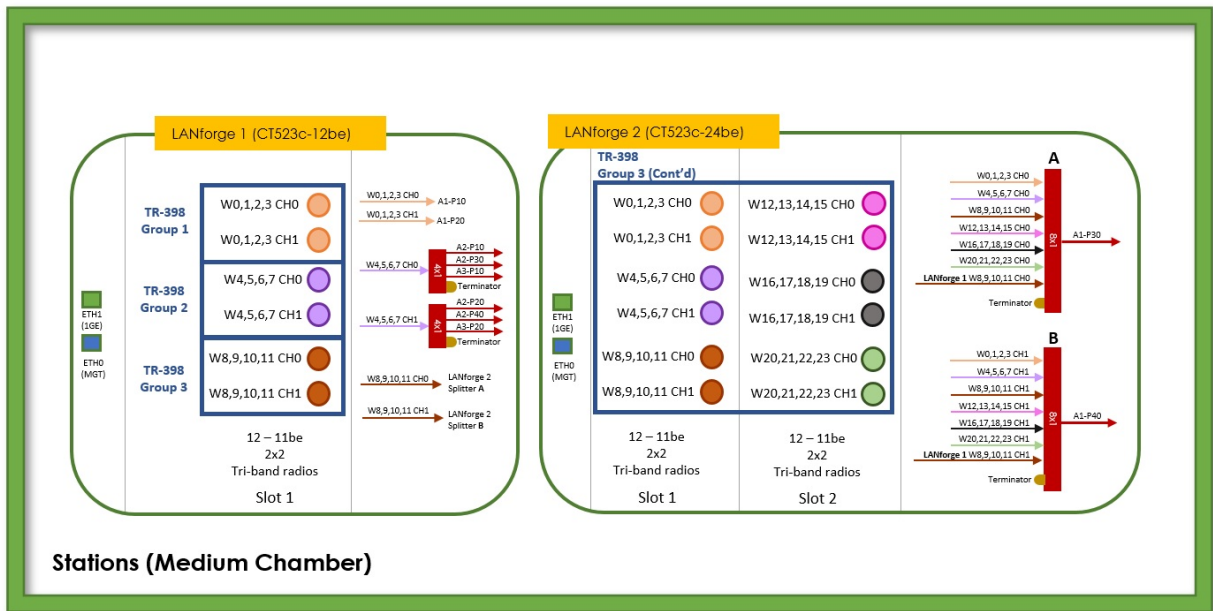


Wiring Diagram for TR398 Issue-4 with Mesh.



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Stations Chamber Details



The test setup, testbed components and environment are all created as per the requirements in Section 5 of the TR-398 Issue 3 test plan document. Some of the components may be different than pictured depending on the options purchased. Please ask your sales representative for details.

TR-398 Issue 3+ Mesh Testbed Images



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TR-398 Issue 3 Testbed Images without Mesh



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More testbed pictures: [CT840b Front](#) | [CT840b Inside](#) | [CT840b Front Open](#) | [CT840b Back](#)

The LANforge GUI provides integrated configuration and automation control for all the components of the testbed including the station emulators, traffic generator, attenuators, and turntables. The entire set of supported TR-398 Issue 4 tests, or optionally a subset of these tests, can be run with a single push of a button. An HTML, PDF, and xlsx report can be generated with a second button click when the test completes.

TR-398 Issue 4 Automated Test (cv-inst-1)

Per-Test Config 3 | Per-Test Config 4 | Per-Test Config 5 | Per-Test Config 6 | Advanced Configuration | Report Configuration | TR398-Issue3

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | Mesh Settings | Mesh Settings 2 | Per-Test Config 1 | Per-Test Config 2

Selected DUT 5G: be800 be800_5g 40:ed:00:14:f5:f3 (2) | Upstream Port: 1.3.2 eth2

Selected DUT 2G: be800 be800_2g 40:ed:00:14:f5:f2 (1) | Multicast Upstream Port: 1.3.2 eth2

Selected DUT 6G: be800 be800_6g 52:ed:00:14:f5:f4 (3) | Turn-Table-Chamber: 840B-Default-Chamber

2.4Ghz 2m RSSI: -25 (Issue-3 default) (-25) | 5Ghz 2m RSSI: -30 (Issue-2/3) (-30)

Skip 2.4Ghz Tests Skip 5Ghz Tests Skip 6Ghz Tests Skip N/AC Tests Skip AX Tests Skip BE Tests

TR-398 Tests to Run: Estimated Test Duration: 25 m

Verify 802.11AX Radios Verify Virt-Sta Radios Verify Group Throughput

Calibrate 802.11AX Attenuators Calibrate Virt-Sta Attenuators

Calibrate Mesh Sta to Root Attenuators Calibrate Mesh Sta to Node-1 Attenuators Calibrate Mesh Root to Node-1 Attenuators

Calibrate Mesh Sta to Node-2 Attenuators Calibrate Mesh Node-1 to Node-2 Attenuators Calibrate Mesh Root to Node-2 Attenuators

6.1.1 Receiver Sensitivity 6.2.6 Latency 6.4.2 Multiple Assoc Stability

6.2.1 Maximum Connection 6.2.7 Quality of Service 6.4.3 Downlink MU-MIMO

6.2.2 Maximum Throughput 6.3.1 Range Versus Rate 6.4.4 Multicast

6.2.3 Airtime Fairness 6.3.2 Spatial Consistency 6.5.1 Long Term Stability

6.2.4 Dual-Band Throughput 6.3.3 Peak Performance 6.5.2 AP Coexistence

6.2.5 Bi-Directional Throughput 6.4.1 Multiple STAs Performance 6.5.3 Automatic Channel Selection

6.2.8 Multi-Band Throughput 6.6.1 Mesh Backhaul RvR 6.6.2 Mesh Backhaul Node-2 RvR 6.6.3 Mesh Roam Time

 Another Iteration
 Pause

Includes these Building Blocks

- **Hardware**

- LANforge CT523c Multi station Emulation and Traffic Generation Hardware – 32 WiFi-7 radios, Multi-Gig Ethernet ports.
- CT521b systems for auto-calibration and for interferer devices needed for some tests.
- CT820a-Medium RF Chambers (rack-mount available).
- CT822a-Medium RF Chambers with internal antenna supports (rack-mount available).
- CT840a or CT840b Large RF Chamber with Programmable Turntable.
- CT714b 4 Port Programmable Attenuators.
- RF Splitters/Combiners.
- Directional Antennas.
- RF Cables.

- **Software**

- TR-398 Issue 4 Automation Software
- Normal LANforge WiFi testing features are included at no additional charge.

Key Tests for TR-398 Issue 4

- Calibration and Testbed Setup
 - Automatic calibration of station attenuators.
 - Automatic calibration of mesh backhaul attenuators.
 - Automatic verification of basic testbed correctness.
- 6.1 RF capability

- 6.1.1 Receiver Sensitivity Test
- 6.2 Baseline performance
 - 6.2.1 Maximum Connection Test
 - 6.2.2 Maximum Throughput Test
 - 6.2.3 Airtime Fairness Test
 - 6.2.4 Dual-band Throughput Test
 - 6.2.5 Bidirectional Throughput Test
 - 6.2.6 Latency under Load Test
 - 6.2.7 Quality of Service Test
 - 6.2.8 Multi-band Throughput Test
- 6.3 Coverage
 - 6.3.1 Range Versus Rate Test
 - 6.3.2 Spatial Consistency Test
 - 6.3.3 802.11ax Peak Performance Test, including 2x2 320Mhz. (**4x4 not supported at this time**)
- 6.4 Multiple Stations Performance
 - 6.4.1 Multiple Stations Performance Test.
 - 6.4.2 Multiple Association/Disassociation Stability Test.
 - 6.4.3 Downlink MU-MIMO Performance Test (**6E not currently supported, not required by TR398i3**).
 - 6.4.4 Multicast Performance Test (not officially part of TR398 Issue4).
- 6.5 Stability/Robustness
 - 6.5.1 Long Term Stability Test
 - 6.5.2 AP Coexistence Test (**6E not currently supported.**)
 - 6.5.3 Automatic Channel Selection Test (**6E not supported at this time**)
- 6.6 Mesh test cases (TR398 issue-3)
 - 6.6.1 Mesh Backhaul Rate vs Range
 - 6.6.2 2-hop Mesh Backhaul Rate vs Range
 - 6.6.3 Mesh Roaming Test
- 7 AP Stability/Robustness
 - 7.1.1 RSSI Accuracy
 - 7.1.2 Channel Utilization Accuracy
 - 7.1.3 Noise Accuracy (**Not supported at this time**)

Many of the features not currently supported by the automation can be executed manually.

Lead Times and Support:

i Please contact support@candelatech.com if you need any assistance.

Lead Times: Four to six weeks.

TaaS/Onsite Support: Customers with only occasional test needs can use our Test as a Service option. Candela engineers can do the testing for you in our fully equipped test lab and provide a detailed test report with recommendations.

For more information, please contact sales@candelatech.com or give us a call at: 1-360-380-1618