

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.
- 6.4.4 Multicast Multi-Station
- 6.4.5 Uplink MU-MIMO
- 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
- 6.2.9 OFDMA 6GHz 31-sta 6GHz 24-sta 6GHz 16-sta 2.4/5GHz 16-sta
- 6.5 Preamble Puncturing.
- 6.5.6 MLO (eMLSR).

TR-398 Issue3 Test Report



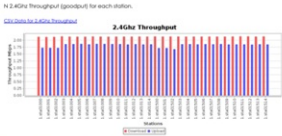
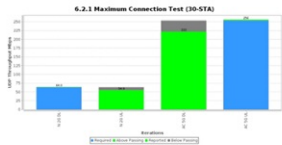
Test Setup Information	
Name	TR-398
SSID	TR-398, TR-398, TR-398
Power	
SSID	
Power	[Blank]
Estimated Run Time	17.5h
Actual Run Time	18.01h

Objective

The TR-398 Issue 3 WiFi Performance test plan by the Broadband forum provides a comprehensive set of tests to qualify the performance of wireless access points (WAP) designed for residential and small office environments. Radio performance, throughput, connection stability, antenna fairness, AP Coexistence, MU-MIMO performance, Spatial Consistency and Long-term Stability are some of the test items included in this test plan. The test plan is designed for service providers (residential in-home WAPs) to qualify the WAPs in the field before deployment and for equipment makers to test during the development of the WAPs. Candela Technologies offers a fully automated TR-398 Issue 3 test system. The user can select from the list of tests available, install test case run file automatically. 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 detailed results for each test.

Summary Results				
Test	Result	Pass/Fail Score	Expected	Info
Calibrate Mesh-Side Antenna RSSI (STA to Node-1)	Passed	0	0	
Calibrate Mesh-Side Antenna RSSI (STA to Node-2)	Passed	0	0	
4.1.1 Receiver Sensitivity Test	Pass Fail	41	2,305.4	N: 2.4GHz Passed 2 / 3 N: 5GHz Passed 10 / 10 N: 6GHz Passed 10 / 10 N: 7GHz Passed 10 / 10 N: 8GHz Passed 10 / 10 N: 9GHz Passed 10 / 10 N: 10GHz Passed 10 / 10 N: 11GHz Passed 10 / 10 N: 12GHz Passed 10 / 10 N: 13GHz Passed 10 / 10 N: 14GHz Passed 10 / 10 N: 15GHz Passed 10 / 10 N: 16GHz Passed 10 / 10 N: 17GHz Passed 10 / 10 N: 18GHz Passed 10 / 10 N: 19GHz Passed 10 / 10 N: 20GHz Passed 10 / 10 N: 21GHz Passed 10 / 10 N: 22GHz Passed 10 / 10 N: 23GHz Passed 10 / 10 N: 24GHz Passed 10 / 10 N: 25GHz Passed 10 / 10 N: 26GHz Passed 10 / 10 N: 27GHz Passed 10 / 10 N: 28GHz Passed 10 / 10 N: 29GHz Passed 10 / 10 N: 30GHz Passed 10 / 10 N: 31GHz Passed 10 / 10 N: 32GHz Passed 10 / 10 N: 33GHz Passed 10 / 10 N: 34GHz Passed 10 / 10 N: 35GHz Passed 10 / 10 N: 36GHz Passed 10 / 10 N: 37GHz Passed 10 / 10 N: 38GHz Passed 10 / 10 N: 39GHz Passed 10 / 10 N: 40GHz Passed 10 / 10 N: 41GHz Passed 10 / 10 N: 42GHz Passed 10 / 10 N: 43GHz Passed 10 / 10 N: 44GHz Passed 10 / 10 N: 45GHz Passed 10 / 10 N: 46GHz Passed 10 / 10 N: 47GHz Passed 10 / 10 N: 48GHz Passed 10 / 10 N: 49GHz Passed 10 / 10 N: 50GHz Passed 10 / 10 N: 51GHz Passed 10 / 10 N: 52GHz Passed 10 / 10 N: 53GHz Passed 10 / 10 N: 54GHz Passed 10 / 10 N: 55GHz Passed 10 / 10 N: 56GHz Passed 10 / 10 N: 57GHz Passed 10 / 10 N: 58GHz Passed 10 / 10 N: 59GHz Passed 10 / 10 N: 60GHz Passed 10 / 10 N: 61GHz Passed 10 / 10 N: 62GHz Passed 10 / 10 N: 63GHz Passed 10 / 10 N: 64GHz Passed 10 / 10 N: 65GHz Passed 10 / 10 N: 66GHz Passed 10 / 10 N: 67GHz Passed 10 / 10 N: 68GHz Passed 10 / 10 N: 69GHz Passed 10 / 10 N: 70GHz Passed 10 / 10 N: 71GHz Passed 10 / 10 N: 72GHz Passed 10 / 10 N: 73GHz Passed 10 / 10 N: 74GHz Passed 10 / 10 N: 75GHz Passed 10 / 10 N: 76GHz Passed 10 / 10 N: 77GHz Passed 10 / 10 N: 78GHz Passed 10 / 10 N: 79GHz Passed 10 / 10 N: 80GHz Passed 10 / 10 N: 81GHz Passed 10 / 10 N: 82GHz Passed 10 / 10 N: 83GHz Passed 10 / 10 N: 84GHz Passed 10 / 10 N: 85GHz Passed 10 / 10 N: 86GHz Passed 10 / 10 N: 87GHz Passed 10 / 10 N: 88GHz Passed 10 / 10 N: 89GHz Passed 10 / 10 N: 90GHz Passed 10 / 10 N: 91GHz Passed 10 / 10 N: 92GHz Passed 10 / 10 N: 93GHz Passed 10 / 10 N: 94GHz Passed 10 / 10 N: 95GHz Passed 10 / 10 N: 96GHz Passed 10 / 10 N: 97GHz Passed 10 / 10 N: 98GHz Passed 10 / 10 N: 99GHz Passed 10 / 10 N: 100GHz Passed 10 / 10
4.2.1 Maximum Connection Test (30-STA)	Pass Fail	15	13,119	Throughput: N: 2.4GHz: 10.1/10.1 DL: 108.3/10.1 Throughput: AC: 30GHz: 10.1/10.1 DL: 108.3/10.1

4.2.2 Maximum TCP Throughput Test	Pass	92	Throughput: N: 2.4GHz: 10.1/10.1 DL: 108.3/10.1 Throughput: AC: 30GHz: 10.1/10.1 DL: 108.3/10.1
4.2.3 Address Fairness Test	Pass	0	AC: 30GHz Passed 0 / 4 N: 2.4GHz Passed 3 / 4
4.2.3 Issue-3 Address Fairness Test	Pass	0	
4.4.4 Multiple STA Multicast Test	Pass	0	
4.2.4 Dual-Band Throughput Test	Pass	45	N: 7 / 12 AC: 4 / 12
4.2.5 Bidirectional UDP Throughput Test	Pass	50	N: 2.4GHz Passed 1 / 3 AC: 30GHz Passed 2 / 3
4.2.6 Latency Test	Pass	0	
4.2.7 Quality of Service Test	Pass	0	
4.3.1 Range Varies Rate Test	Pass	98	N: 2.4GHz: 10.1 / 17.0, 3 / 17 AC: 30GHz: 10.1 / 14.0, 8 / 14
4.3.2 Spatial Consistency Test	Pass	0	Interfered ERROR: Rotation table Failed for rotate N: 2.4GHz Passed 0 / 0 AC: 30GHz Passed 0 / 0 N: 2.4GHz Passed 0 / 0 AC: 30GHz Passed 0 / 0
4.3.3 AP Peak Performance TCP Throughput Test	Pass	0	
4.4.1 Multiple STA Performance Test	Pass	23	N: 2.4GHz Passed 4 / 6 AC: 30GHz Passed 0 / 6
4.4.2 Multiple Association / Disassociation Stability Test	Pass	94	N: 2.4GHz Passed 15 / 14 AC: 30GHz Passed 14 / 14
4.4.3 Downlink MU-MIMO Performance Test	Pass	0	
4.5.2 AP Coexistence Test	Pass	156	Passed 4 / 8 NOTE: Auto-Calibrated Interferer Interferer: 100mW SG: 80MHz AC: 133.33 Mbps SG: 40MHz AC: 14.29 Mbps 2.4GHz 30MHz N: 23.40 Mbps
4.5.3 Automatic Channel Selection	Pass	0	
5.1.1 Mesh Backhaul B/W	Pass	0	
5.1.2 Mesh Backhaul Node-2 B/W	Pass	0	
5.2.1 Mesh Room Time	Pass	0	



Max Cx Test: Snapshot N: 2.4GHz Download	
Test	Result
4.2.1 Maximum Connection Test (30-STA)	Pass
4.2.2 Maximum TCP Throughput Test	Pass
4.2.3 Address Fairness Test	Pass
4.2.3 Issue-3 Address Fairness Test	Pass
4.4.4 Multiple STA Multicast Test	Pass
4.2.4 Dual-Band Throughput Test	Pass
4.2.5 Bidirectional UDP Throughput Test	Pass
4.2.6 Latency Test	Pass
4.2.7 Quality of Service Test	Pass
4.3.1 Range Varies Rate Test	Pass
4.3.2 Spatial Consistency Test	Pass
4.3.3 AP Peak Performance TCP Throughput Test	Pass
4.4.1 Multiple STA Performance Test	Pass
4.4.2 Multiple Association / Disassociation Stability Test	Pass
4.4.3 Downlink MU-MIMO Performance Test	Pass
4.5.2 AP Coexistence Test	Pass
4.5.3 Automatic Channel Selection	Pass
5.1.1 Mesh Backhaul B/W	Pass
5.1.2 Mesh Backhaul Node-2 B/W	Pass
5.2.1 Mesh Room Time	Pass

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Key Measurements

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

Overview

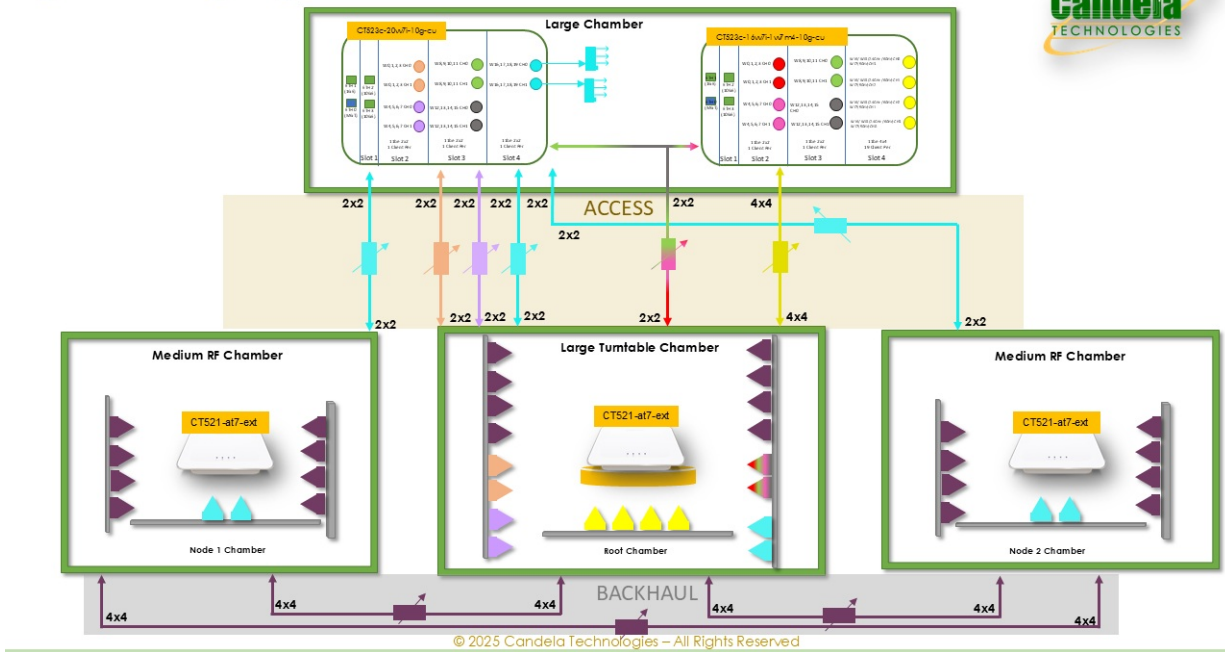
TR-398 Issue 3 Overview Video

Slide presentation for Candela Technologies' TR-398 issue 4 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.

High Level Wiring Diagram for TR398 Issue-4 with Mesh.

High Level Wiring Diagram



Contact Sales/Support for full wiring diagram.

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.

TR398 issue-4 with 1 mesh extender, 32 Intel be200 Radios.



TR398 issue-4 with 2 mesh extenders plus 3rd-party devices chamber, 32 Intel be200 Radios plus 6 virtual station radios.



TR398 issue-4 with 2 mesh extenders in single 80db chamber stack with side-mount attenuators and custom cable lengths for clean cabling. 32 Intel be200 Radios plus 1 tri-band tri-concurrent virtual station radio.





Other views of this testbed: [CT840b-ss Front Top](#) | [CT840b-ss Back](#) | [CT840b-ss Right Side](#) | [CT840b-ss Left Side](#)

More testbed pictures: [CT840b Front](#) | [CT840b Inside](#) | [CT840b Front Open](#) | [CT840b Back](#) | [CT840b Mesh Diag](#) | [Mesh Chamber Stack-A](#)

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-0)

Mesh Settings 2 | Individual Test Configuration | Advanced Configuration | Report Configuration | TR398-Issue4 | Report ↑ ✖

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | Mesh Settings

Selected DUT 5G: [Dropdown] Upstream Port: 1.3.2 LAN [Dropdown]
 Selected DUT 2G: [Dropdown] Multicast Upstream Port: 1.1.2 eth2 [Dropdown]
 Selected DUT 6G: [Dropdown] Turn-Table-Chamber: 8408-Default-Chamber [Dropdown]
 2.4Ghz 2m RSSI: -25 (Issue-3 default) (-25) [Dropdown] 5Ghz 2m RSSI: -30 (Issue-2/3) (-30) [Dropdown]

☐ Skip 2.4Ghz Tests ☐ Skip 5Ghz Tests ☐ Skip 6Ghz Tests ☐ Skip N/A/C Tests ☐ Skip AX Tests ☐ Skip BE Tests

TR-398 Tests to Run: Estimated Test Duration: 1.417 h

☐ 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 ☐ 7.1.1 RSSI Accuracy ☐ 7.1.2 Channel Utilization
☐ 6.2.9 OFDMA Throughput ☐ 6.5.5 Puncturing
☒ 6.6.1 Mesh Backhaul RvR ☒ 6.6.2 Mesh Backhaul Node-2 RvR ☒ 6.6.3 Mesh Roam Time

Test is complete. Start Skip ☐ Another Iteration ☐ Pause Cancel

More testbed screen shots: [Virtual-Stations](#) | [BE Stations](#) | [More BE Stations](#) | [Mesh Setup](#) | [Mesh Setup 2](#) | [Per-Test Configuration](#) | [Report Configuration](#) | [Upcoming Tests](#)

Includes these Building Blocks

- **Hardware**

- LANforge CT523c Multi station Emulation and Traffic Generation Hardware – 32 WiFi-7 radios, Multi-Gig Ethernet ports.
- CT521-at7-ext systems for auto-calibration and for interferer devices needed for some tests.
- Medium RF Chambers (stackable and rack-mount available).
- Medium RF Chambers with internal antenna supports (stackable and rack-mount available).
- Large RF Chamber with Programmable Turntable (For example, [80db Chamber Stack](#))
- CT714b, CT718 and/or CT714c-at Programmable Attenuators.
- RF Splitters/Combiners.
- Directional Antennas.
- High quality flexible 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 320MHz supported with mtk7996 radio)**
- 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.
 - 6.4.4 Multicast Performance Test (not officially part of TR398 Issue4).
 - 6.4.5 Uplink MU-MIMO Performance test.
 - 6.2.9 OFDMA Performance Test (pending for TR398 Issue4).
 - 6.5.5 Preamble Puncturing (requires wifi-7 capable testbed).
 - 6.5.6 MLO (eMLSR) (requires wifi-7 capable testbed).
- 6.5 Stability/Robustness
 - 6.5.1 Long Term Stability Test
 - 6.5.2 AP Coexistence Test
 - 6.5.3 Automatic Channel Selection Test
- 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 Accuracy
 - 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.

Testbed Options

Test Case	Stations	STA Chamber	DUT Chamber	Mesh Chambers	CT521	Attenuators
6.1.1 RX Sensitivity	1	1	1 2D	0	1	1
6.2.1 Max Connection	32	1	1	0	1	2

6.2.2 Max Throughput	1	1	1	0	1	1
6.2.3 Airtime Fairness	2	1	1	0	1	1
6.2.4 Dual-Band Throughput	2	1	1	0	1	1
6.2.5 Bi-Directional Throughput	1	1	1	0	1	1
6.2.6 Latency under Load	32	1	1	0	1	2
6.2.7 Quality of Service	1	1	1	0	1	1
6.2.8 Multi-Band Throughput	3	1	1	0	1	2
6.2.9 Downlink OFDMA	32	1	1	0	1	2
6.3.1 Rate vs Range	1	1	1	0	1	1
6.3.2 Spatial Consistency	1	1	1 2D	0	1	1
6.3.3 Peak Performance	1	1	1	0	1	1
6.4.1 Multi-STA Performance	9	1	1	0	1	2
6.4.2 Multi-Assoc Stability	16	1	1	0	1	2
6.4.3 Downlink MU-MIMO	3	1	1	0	1	1
6.4.4 Multicast	9	1	1	0	1	2
6.4.5 Uplink MU-MIMO	3	1	1	0	1	1
6.5.1 Longterm Stability	6	1	1	0	1	2
6.5.2 AP Coexistence	1	1	1	1	2	3
6.5.3 Automatic Channel Selection	1	1	1	0	1	1
6.5.4 BSS Color	1	1	1	2	3	6
6.5.5 Preamble Puncturing	2	1	1	0	1	1
6.5.6 MLO (eMLSR)	3	1	1	0	1	1
6.6.1 Mesh Backhaul RvR	1	1	1	1	2	3
6.6.2 2-hop Mesh Backhaul RvR	1	1	1	2	3	6
6.6.3 Mesh Roam	1	1	1	1	2	3
Non-Mesh Testbed	32	1	1 2D	0	1	2
1 Extender Mesh Testbed	32	1	1 2D	1	2	3
2 Extender Mesh Testbed	32	1	1 2D	2	3	6

Budgetary Price Range

Testbed Option	Price Range
Non-Mesh Basic TR398i4 with Full Isolation Stackable chambers	\$260k
1 Extender Mesh TR398i4 with Full Isolation Stackable chambers	\$315k
2 Extender Mesh TR398i4 with Full Isolation Stackable chambers	\$375k
Non-Mesh Basic TR398i4 with 80db Isolation Chambers	\$225k
1 Extender Mesh TR398i4 with 80db Isolation Chambers	\$265k
2 Extender Mesh TR398i4 with 80db Isolation Chambers	\$310k
Non-Mesh Basic TR398i4 with 70db Isolation Chambers	\$220k
1 Extender Mesh TR398i4 with 70db Isolation Chambers	\$255k
2 Extender Mesh TR398i4 with 70db Isolation Chambers	\$295k
Other options Available, contact sales@candelatech.com for a detailed quote	

Yearly support, shipping, on-site install not included in the prices above. Other options are available.

Lead Times and Support:

 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

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