# CarPlay Wireless Performance Test Guide

Release R7

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# 1. Introduction

This document describes test procedures for CarPlay over wireless that evaluate the following:

- Wi-Fi access point performance
- Coexistence with other wireless technologies in the car
- Overall CarPlay over wireless experience

These tests are required for all new systems that support CarPlay over wireless.

If the same system is deployed in subsequent car models, it is your responsibility to perform these tests for each car model with unique wireless characteristics (e.g. antenna position, materials, or the presence of other wireless technologies) to ensure that performance requirements are met. Test results for subsequent car models do not need to be submitted to Apple, unless requested.

# 2. Test Environments

The tests described in this document are performed in one or more of the following environments. See the test descriptions for details on which environments are used with each test.

| Environment | Definition |
|---|---|
| Clean | • Perform the test inside a stationary vehicle.<br>• Turn off all nearby Wi-Fi access points, Bluetooth devices and other known radios.<br>• Use a Wi-Fi spectrum analyzer inside the vehicle to confirm that the noise floor is lower than -90 dBm across the frequency band and channel under test. |
| Congested | • Perform the test inside a stationary vehicle.<br>• Turn on 3 Wi-Fi access points outside of the vehicle configured as follows:<br>- If your system operates using 2.4 GHz, configure the first access point to use the CarPlay operating channel and run bi-directional UDP traffic at max 5 Mbps (Server: iperf -s -i 1 -w 512k -u / Client: iperf -c x.x.x.x -i 1 -w 512k -t MAX_TEST_TIME -u -b 5M). Configure the two other access points to use the remaining 2.4 GHz channels and run bi-directional UDP traffic capped at 40 Mbps (Server: iperf -s -i 1 -w 512k -u / Client: iperf -c x.x.x.x -i 1 -w 512k -t MAX_TEST_TIME -u -b 40M).<br>- If your system operates using 5 GHz, configure the first access point to use the CarPlay operating channel and run bi-directional UDP traffic at max 5 Mbps (Server: iperf -s -i 1 -w 512k -u / Client: iperf -c x.x.x.x -i 1 -w 512k -t MAX_TEST_TIME -u -b 5M). Configure the second access point to use one channel higher and the third access point to use one channel lower than the CarPlay operating channel. Run bi-directional UDP traffic at capped at 40 Mbps on the second and third access points (Server: iperf -s -i 1 -w 512k -u / Client: iperf -c x.x.x.x -i 1 -w 512k -t MAX_TEST_TIME -u -b 40M).<br>• Use a Wi-Fi spectrum analyzer inside the car with closed doors to confirm that the noise floor is higher than -70 dBm across the frequency band and channel under test. |
| City | • Perform the test inside a moving vehicle.<br>• Drive a pre-defined route in a congested city environment.<br>• Use a Wi-Fi spectrum analyzer inside the car with closed doors to confirm that the noise floor is higher than -70 dBm across the frequency band and channel under test. |

# 3. Passing Criteria

All systems that support CarPlay over wireless must meet the following criteria.

## 3.1 Performance requirements

| Key Performance Indicator | Requirements | | |
|---|---|---|---|
| TCP bi-directional throughput | Main display only (no instrument cluster display) | Main + 1 instrument cluster display | Main + 2 instrument cluster displays |
| | At least 19 Mbps | At least 29 Mbps | At least 39 Mbps |
| UDP bi-directional throughput | At least 6 Mbps | | |
| Latency | Average less than 16 ms | | |
| Packet loss | Less than 1% | | |

## 3.2 Overall CarPlay over wireless experience requirements

| Key Performance Indicator | Requirements |
|---|---|
| CarPlay audio distortions | No audible distortion or skips during playback for all audio types (e.g. phone calls, media playback, notifications and turn-by-turn navigation) |
| CarPlay video artifacts | No visual distortion or choppiness during video playback for all features (e.g. turn-by-turn navigation and launching apps). |
| CarPlay subjective latency | No noticeable audio/video delay or loss of synchronization for all features (e.g. turn-by-turn navigation, phone calls, Siri, user input) |
| CarPlay stability | No disconnects or dropped sessions |

## 3.3 System integration requirements

It is expected that there is no noticeable interference on other wireless technologies through Apple CarPlay. Bluetooth audio quality, personal Hotspot throughput and latency, etc. should offer usable customer experience.

# 4. Tools

## 4.1 The following tools are required to perform the tests

- CarPlay Tests app version 2.10 or above
- iPerf v2.0.9 or newer
- ping
- Ellysis or Frontline Test Equipment BPA 600 Bluetooth protocol analyzer
- Wi-Fi spectrum analyzer set to the CarPlay operating band with output saved as images (e.g. *Wi-Spy*)
- Wi-Fi packet analyzer set to the CarPlay operating channel with output saved as .pcap (e.g. *Wireshark with AppleIE.lua plugin installed*)

Installation instructions

1. Install Wireshark 3.2.1 or newer

2. Create a folder named: /Users/<username>/.config/wireshark/plugins

3. Copy appleie.lua to this location

4. Restart Wireshark

5. Open Wireshark Menu->About Wireshark->Folders

Confirm the plugin is listed as shown below

Personal Plugins /Users/<username>/.config/wireshark/plugins dissector plugins

6. Open Menu->About Wireshark->Plugins Tab

Confirm appleie.lua is listed and linked correctly

7. Confirm the correct Apple Device IE decoding:

Open a capture file and find a 802.11 Broadcast Beacon Frame

Under Apple Device IE you should see:

Apple Device IE

Sub-type 0x00

Flags: 0021

Supports CarPlay over Wireless

Supports 5 GHz Wi-Fi

# 4.2 Tool available for automated solutions (Optional)

DEKRA TACS4 Performance Tool is an automated solution provided by DEKRA to perform all CarPlay over wireless Performance and Coexistence tests required for CarPlay certification. The solution includes test suite management software, client software, an iOS app, and hardware that can be loaned, leased, or purchased from DEKRA. The hardware can also be purchased from another source.

Test Bed: TACS4 controller is DEKRA's test suite management software for running Wireless CarPlay Performance and Coexistence tests. This software is available on the Microsoft Windows platform.

Test Agent (Head Unit):  TACS4-Agent is an endpoint client software developed and supplied by DEKRA. The test agent application code is compiled based on the Head unit OS and then installed. Installation onto the Head unit OS is required for the test execution. This software agent helps automate TCP and UDP data streams between the Head Unit and Apple Device.

Test Agent (Apple Device): TACS4-Agent is an iOS App provided by DEKRA and available in the Apple App Store as "DEKRA TACS4-Agent". This software agent helps automate TCP and UDP data streams between the Head Unit and Apple Device.

Licensees may upload the results generated by DEKRA's TASC4 Performance Tool directly into the MFi Certification Hub under the Wireless CarPlay Performance results section.

Please contact DEKRA for software and hardware licensing, pricing and other terms & conditions. DEKRA provides detailed testing steps and initial setup assistance as part of the software licensing purchase agreement.

# 5. Commands

The following commands are used during testing. The CarPlay Tests app must be used to run the commands on the Apple device.

| Tool | Requirement | Test steps |
|---|---|---|
| ping | Start ping and leave it running | 1. Connect the Apple device to the Wi-Fi Access point<br>2. Allow incoming ping request on the accessory<br>3. Start ping on the Apple device by running: *ping x.x.x.x*<br><br>Measure and record the latency values. |
| TCP UL | Verify that the Wi-Fi access point supports at least 19 Mbps of bandwidth (as measured with iperf) with an average latency less than 16 ms (as measured with the ping command).<br><br>*If the accessory supports an instrument cluster display:*<br><br>Also verify that an additional UL TCP stream of at least 10Mbps is supported.<br><br>*If the accessory supports 2 instrument cluster displays:*<br><br>Also verify that 2 additional UL TCP streams of at least 10Mbps each are supported. | 1. Connect the Apple device to the Wi-Fi Access point<br>2. Start TCP iPerf server on the accessory by running:<br>*iperf -s -i 1 -w 176k*<br>3. Start TCP iPerf client on the Apple device by running: *iperf -c x.x.x.x -i 1 -w 176k -b 20M -t 120 -S 0xA0*<br><br>Measure and record the throughput. |

| | | |
|---|---|---|
| TCP DL | Verify that the Wi-Fi access point supports at least 19 Mbps of bandwidth (as measured with iperf) with an average latency less than 16 ms (as measured with the ping command).<br><br>*If the accessory supports an instrument cluster display:*<br><br>Also verify that an additional DL TCP stream of at least 10Mbps is supported.<br><br>*If the accessory supports 2 instrument cluster displays:*<br><br>Also verify that 2 additional DL TCP streams of at least 10Mbps each are supported. | 1. Connect the Apple device to the Wi-Fi Access point<br>2. Start TCP iPerf server on the Apple device by running<br>*iperf -s -i 1 -w 176k*<br>3. Start TCP iPerf client on the accessory by running:<br>*iperf -c x.x.x.x -i 1 -w 176k -b 20M -t 120 -S 0xA0*<br><br>*If the accessory supports an instrument cluster display:*<br><br>4. *iperf -c x.x.x.x -i 1 -w 176k -b 20M -t 120 -S 0xA0 -b 10M*<br><br>*If the accessory supports 2 instrument cluster displays:*<br><br>5. *iperf -c x.x.x.x -i 1 -w 176k -b 20M -t 120 -S 0xA0 -b 10M*<br><br>Measure and record the throughput. |
| UDP DL | Verify that the Wi-Fi access point supports at least 6 Mbps of bandwidth (as measured with iperf) with an average latency less than 16 ms (as measured with the ping command) and a packet loss of no more than 1%. | 1. Connect the Apple device to the Wi-Fi Access point<br>2. Start UDP iPerf server on the Apple device by running:<br>*iperf -s -i 1 -w 512k -u*<br>3. Start UDP iperf client on the accessory by running:<br>*iperf -c x.x.x.x -i 1 -w 512k -t 120 -u -b 2M -S 0xE0*<br><br>Measure and record the throughput and the packet loss. |
| UDP UL | Verify that the Wi-Fi access point supports at least 6 Mbps of bandwidth (as measured with iperf) with an average latency less than 16 ms (as measured with the ping command) and a packet loss of no more than 1%. | 1. Connect the Apple device to the Wi-Fi Access point<br>2. Start UDP iPerf server on the accessory by running:<br>*iperf -s -i 1 -w 512k -u*<br>3. Start UDP iPerf client on the Apple device by running: *iperf -c x.x.x.x -i 1 -w 512k -t 120 -u -b 4M -S 0xE0*<br><br>Measure and record the throughput and the packet loss. |

| | | |
|---|---|---|
| Simulated Hotspot UDP - With 1 Client | Run on non-CarPlay devices to simulate Hotspot traffic during co-existence tests | 1. Connect the client to the Wi-Fi Access point<br>2. Start UDP iPerf server on each client by running:<br>*iperf -s -i 1 -w 512k -u*<br>3. Start UDP iPerf client on the head unit by running:<br>*iperf -c x.x.x.x -i 1 -w 512k -t 120 -u -b 15M* -S 0xE0<br><br>Measure and record the throughput and the packet loss. |
| Simulated Hotspot UDP - With 2 Clients | Run on non-CarPlay devices to simulate Hotspot traffic during coexistence tests | 1. Connect both clients to the Wi-Fi Access point<br>2. Start UDP iPerf server on each client by running:<br>*iperf -s -i 1 -w 512k -u*<br><br>3. Start a UDP iPerf stream to client 1 on the head unit by running:<br>*iperf -c x.x.x.x -i 1 -w 512k -t 120 -u -b 15M -S 0xE0*<br><br>4. Start a UDP iPerf stream to client 2 on the head unit by running:<br>*iperf -c x.x.x.x -i 1 -w 512k -t 120 -u -b 10M -S 0xE0*<br><br>Measure and record the throughput and the packet loss. |

# 6. Wi-Fi Access Point Performance Tests

Wi-Fi access point performance tests verify the performance of the CarPlay access point. In these tests, only one device is connected to the system. Coexistence with other devices or wireless technologies is not measured by this test.

Wi-Fi access point performance tests must be performed as soon as the access point is operational. CarPlay is not required to be functional. In fact, it is recommended that CarPlay is not active when the tests are performed.

Wi-Fi access point performance must be tested under the following conditions.

- Test environment: *Clean*
- iPhone placement: Front cup holder
- Repeat the test for all supported Wi-Fi frequency bands and channels

Passing criteria:

- Performance requirements

# 7. Coexistence Tests

Coexistence tests verify the performance of the CarPlay access point when used at the same time as other wireless technologies in the vehicle.

Licensees must list all wireless technologies that can be installed in the vehicle in the CarPlay Configuration Record (see CarPlay Certification Guide). Based on the wireless technologies that can be installed in the car, a coexistence test matrix will be defined and approved by Apple. The coexistence test matrix takes into account the following wireless features and is customized for each accessory's configuration.

- Simulated CarPlay traffic
- Classic Bluetooth profiles (for classic Bluetooth usage with a secondary phone)
- Personal Hotspots (simulate Hotspot activity based on the number of supported clients)
- Proprietary wireless link (e.g. Bluetooth headphones, rear seat tablets, etc.)
- Additional services on the CarPlay access point (e.g. 3rd party app streaming services)

Coexistence tests must be executed as soon as the access point is operational. CarPlay is not required to be functional. In fact, it is recommended that CarPlay is not active when the tests are performed.

Coexistence tests must be performed under the following conditions.

- Test environments: *Clean* and *Congested*
- iPhone placement: Front cup holder
- iPhone must be signed into iCloud
- iPhone must not be paired with Apple Watch
- If more than one frequency band or channel is supported, repeat the test as follows:
    - One supported channel in the 2.4 GHz band (channels 1, 6, or 11)
    - One supported channel in the lower 5 GHz band (channels 36, 40, 44, or 48)
    - One supported channel in the upper 5 GHz band (channels 149, 153, 157, 161, or 165)

Passing criteria:

- Performance requirements
- System integration requirements

# 8. Wireless Drive Test

Wireless drive tests verify overall CarPlay performance in real world scenarios.

Drive tests must be performed under the following conditions:

- Test environments: *City*
- iPhone placement: Front cup holder
- iPhone must be signed into iCloud
- iPhone must be paired and connected to Apple Watch
- Perform the test using the default Wi-Fi frequency band and channel
- All tests (except reconnects) must be performed sequentially without powering off the accessory
- Perform the wireless drive test in a city environment that meets the environmental conditions defined in section 2 - Test Environments
- If the accessory offers Internet data on the CarPlay Wi-Fi access point (Hotspot), additional setup and tests are required:
    - The vehicle must be equipped with an active Internet subscription or data plan
    - The accessory must be able to activate or deactivate the Hotspot (operable by the licensee's onsite support engineer during the audit)
    - Perform Hotspot connectivity tests as outlined in the Wireless Drive Test Plan

Passing criteria:

- Overall CarPlay over wireless experience requirements
- System integration requirements

Before performing wireless drive tests, enable *sysdiagnose* and *Wi-Fi* logging on the test iPhone by installing the required profiles. See the following page for details on profiles and logs.

Profiles and Logs
http://developer.apple.com/bug-reporting/profiles-and-logs/

# 9. Revision History

This tables describes the changes to *Wireless Performance Test Guide*.

| Release | Notes |
| --- | --- |
| 2022-11-30<br>Release R7 | Added Tools available for automated solutions.<br>Replaced ATS Utility App references with CarPlay Tests app.<br>Updated requirement for reporting of vehicle installed wireless technologies. |
| 2021-01-22<br>Release R6 | Updated Performance requirements to include instrument cluster configurations.<br>Updated required version for ATS Utility App.<br>Updated Commands chapter to support instrument cluster tests.<br>Updated Wireless Drive Test section to include Hotspot test requirements. |
| 2020-01-24<br>Release R5 | Clarified passing criteria.<br>Updated required version for ATS Utility App, iPerf, and Wireshark. Updated Commands chapter.<br>Remove test result submissions. |
| 2018-01-22<br>Release R4 | Updated Congested Test Scenario with example UDP commands<br>Updated Tools section with AppleIE.lua script<br>Updated Commands chapter |
| 2017-09-01<br>Release R3 | Clarified test procedures for additional car models.<br>Clarified required version for the ATS Utility app.<br>Updated UDP and ping commands.<br>Clarified conditions for co-existence tests.<br>Updated the *Wireless Performance Test Plan* and *Wireless Coexistence Test Plan*. |
| 2017-04-10<br>Release R2 | Updated the UDP test in *Commands* line 8 to support bi-directional data. |
| 2016-12-19<br>Release R1 | First release. |