2021
FCC Speed Test App
Technical Description

Office of Engineering and Technology

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I. Introduction

This technical description document ("the App Description") for the FCC Speed Test mobile application ("the FCC Speed Test App" or "the App")[1] provides detailed information on the metrics and methodologies used by the FCC Speed Test App to conduct connection performance tests on mobile broadband networks. The App Description includes reviews of the techniques implemented for mobile network performance measurement, including the test sequence and methodologies, environmental data for Android and iOS operating systems, data reporting features, and an overview of the backend test system architecture.[2]

II. Mobile Broadband Performance Testing

This section describes the technical features of the supporting system architecture and the FCC Speed Test App, as well as other technical aspects of the methods employed to measure mobile broadband performance.[3]

A. FCC Speed Test Methodology Overview

The App's technologies and methodologies are developed collaboratively with a technical solutions contractor, SamKnows, Inc.[4] The contractor supports the FCC's efforts to develop and maintain the App.

The FCC Speed Test App has two independent mobile applications due to the differences between iOS and Android operating systems, security features, and hardware. The iOS App is written in the Swift programming language and the Android version is written in the Kotlin programming language.

The iOS operating system supports iPhone and iPad hardware devices. The iOS operating system's security features do not expose many of the radio parameters that the FCC Speed Test App relies on to verify the network environment. Additionally, the iOS operating system (unlike the Android operating system) allows only for tests to be performed manually in the foreground and does not allow for automated scheduled testing of the FCC Speed Test.

[1] The FCC Speed Test App is available for both Android devices from Google Play, at https://play.google.com/store/apps/details?id=com.samknows.fcc&hl=en, and for iOS devices from the Apple App Store, at https://apps.apple.com/us/app/fcc-speed-test/id794322383.

[2] The FCC recently contracted for updates to the App to implement additional capabilities for submitting mobile challenge and crowdsource data as part of the FCC's Broadband Data Collection program, https://sam.gov/opp/cbd05b3514244c62996ef84ce734ea37/view. OET intends to publish a revised version of this technical description document in the future that includes additional details on the BDC functionalities of the App upon release of an updated version of the App.

[3] This 2021 Technical Description updates the earlier 2016 and 2018 versions to describe the FCC Speed Test app currently in use.

[4] *See generally* https://www.samknows.com/.

The Android operating system is supported on hardware devices from multiple different vendors such as Google, Samsung, Motorola, Nokia, etc. The Android operating system provides a consistent Application Programming Interface (API), which exposes many radio parameters for use by applications. Many mobile device vendors support the radio parameters that the FCC Speed Test relies on to verify the network environment.

1. Measurement Process

The measurements that provide the underlying data rely both on the measurement client that initiates the test process and measurement servers that function as a test endpoint to the client's measurements. The measurement client consists of a publicly available app, the FCC Speed Test App, which can be obtained at no cost without in-app ads and has been downloaded on hundreds of thousands of Android and iOS devices in locations across the nation.[5] Measurement tests can be performed on any mobile broadband service provider's network subscribed to by consumers running the App.

Currently, the measurement servers are hosted by StackPath and are located in ten cities (thirteen locations, some cities with multiple sites) across the United States near a point of interconnection between the broadband provider's network and the network on which the measurement server resides. Section F provides details of the thirteen measurement servers.

This methodology focuses on the performance of the specific mobile broadband network under test. When a test sequence initiates, the App will check whether the form of connection is cellular or Wi-Fi. If the connection is over a cellular network, the App will further identify its connection technology type; *i.e.*, 3G, 4G, or 5G. If the connection is over a Wi-Fi network, the App will test and report the performance of the Wi-Fi network connection through its connected Internet service.

Once the App selects a measurement server, the metrics are derived from traffic exchanged between a measurement client (the App) and the selected measurement server. The tests use the measurement server for which the latency between the measurement client and server is the lowest value, which means that the selected server may not be geographically the closest from the measurement client location. As a result, the metrics measure performance along a specific path within each mobile broadband provider's network, through the point of interconnection between the mobile broadband provider's network, and the network on which the chosen measurement server resides.

[5] The FCC Speed Test App Privacy Notice and Terms of Use for the FCC Speed Test App describes the steps taken to protect each user's privacy. *See* FCC, *FCC Speed Test App Privacy Notice and Terms of Use,* https://www.fcc.gov/general/mobile-broadband-performance-application-privacy-notice-and-terms-use. (last visited Nov. 1, 2021). The policy and technical measures of the test architecture, client and data processing protect personally identifiable information (PII) of the mobile devices reporting results to the FCC.

2. Testing and Performance Metrics

Each test sequence is preceded by the measurement client selecting a test server as follows:

- Test server selection: Measures and compares for the lowest round-trip time by ICMP ping (default for Android) or TCP ping (default for iOS and fallback for Android) from the 10 nearest servers typically over 2 seconds with a 10-second timeout if servers fail to respond.

Once the server is selected, the App performs the following active tests of mobile broadband performance:

- Download speed: Measures the average download speed in megabits per second over a maximum 8-second time interval to transmit up to 1,000 megabytes (MB). This includes a fixed 3-second warmup period (*i.e.*, 3 seconds warm-up and 5 seconds testing).
- Upload speed: Measures the average upload speed in megabits per second over a maximum 8-second time interval to transmit up to 1,000 megabytes (MB). This includes a fixed 3-second warmup period (*i.e.*, 3 seconds warm-up and 5 seconds testing).
- Latency: Measures the average round-trip time in milliseconds of up to 200 UDP (User Datagram Protocol) data packets that are acknowledged as received individually within 2 seconds or are recorded as lost. The packets are sent over a fixed 5-second time interval. No warm-up period is applied to latency.
- Packet Loss: The ratio of the number of UDP packets either not acknowledged by the measurement server, or acknowledged as received after 2 seconds, to the number of total packets sent from the client.
- Jitter: The amount of variation in latency measured in milliseconds. Jitter is calculated across all packets (up to 200 packets, assuming no loss) using the Packet Delay Variation (PDV) approach.

A more detailed discussion of the measurement test methodology is presented in Section C, below.

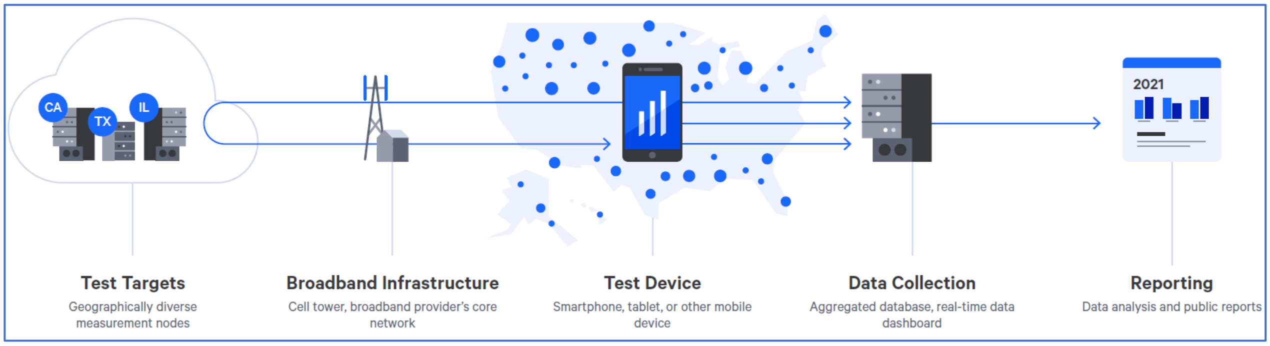
B. Test System Architecture

The test system architecture focuses on measuring the performance of mobile broadband networks. The measurement servers are located across the U.S., which are hosted by a major content delivery network (CDN) with servers in proximity at multiple Internet exchange points/peering locations for unbiased network performance measurement.

As illustrated below in Figure 1, the App executes tests, as part of the measurement system that comprises a distributed network of “Test Devices” (*i.e.*, measurement clients), used to accurately measure the performance of mobile broadband connections based on real-world usage. Upon completion of each test sequence, the App reports measurement results to the reporting database (“Data Collection”), where the data is collated on the reporting platform (“Reporting”). The App measures download and upload speeds, round-trip latency, packet loss, and jitter by exchanging information with the selected measurement servers ("Test Targets"), which the App contacts when a Test Device manually initiates a test sequence or according to the test schedule if prescheduled in Android.

The measurement servers, each supporting a 100 Gbps capacity, used for mobile broadband measurement are hosted by StackPath and are distributed nationally to enable a measurement client to select the host server with the least latency.

Figure 1: Mobile Broadband Test Architecture


CA
TX
IL
2021
Test Targets
Geographically diverse measurement nodes
Broadband Infrastructure
Cell tower, broadband provider's core network
Test Device
Smartphone, tablet, or other mobile device
Data Collection
Aggregated database, real-time data dashboard
Reporting
Data analysis and public reports

C. Download Speed and Upload Speed

Two separate tests measure the download and upload speed in megabits per second by establishing multi-TCP connections to perform HTTP GET and POST requests to a target test node. Binary non-zero content, herein referred to as the payload, is hosted on a web server on the target test node. Each test cycle begins with a fixed 3-second warmup, followed by the download or upload speed test. Each speed test concludes either after 1,000 MB of payload is transferred or after a maximum elapsed time period of 5 seconds. The total time for the test cycle is thus no more than 8 seconds, and the client will attempt to download as much of the payload as possible for the duration of the test. The payload and all other testing parameters are configurable and may be subject to change in the future.

Tests are executed using three concurrent TCP connections for byte streams. Hence, each connection used in the test counts the numbers of bytes of the target payload transferred between two points in time, and calculates the speed of each thread as the number of bits transferred over the number of seconds in the active test window. The speeds of the three threads are then summed to determine the total speed.

Factors such as TCP slow start are taken into account by transferring a portion of the target payload before the real testing begins. This "warmup" period will complete after a fixed duration of three seconds. Three individual connections are established, each on its own thread, and are confirmed as all having completed the warmup period before the five-second timing begins.

Content downloaded is copied to /dev/null or equivalent (*i.e.*, it is discarded). Payload content for upload tests is generated and streamed on the fly from /dev/urandom (or equivalent).

The following is an example of the calculation performed for a multi-connection test using three concurrent TCP connections:

- S = Speed (Bytes per second)
- B = Bytes (Bytes transferred)
- T = Time (Seconds) (between start time point and end time point)
- S1 = B1 / T1 (speed for Thread 1 calculation)
- S2 = B2 / T2 (speed for Thread 2 calculation)
- S3 = B3 / T3 (speed for Thread 3 calculation)
- Speed = S1 + S2 + S3
- Example values from a 3 MB payload:
- B1 = 3077360 T1 = 15.583963
- B2 = 2426200 T2 = 15.535768
- B3 = 2502120 T3 = 15.536826
- S1 = B1/T1 = 197469.668017
- S2 = B2/T2 = 156168.655454
- S3 = B3/T3 = 161044.475879
- S1 + S2 + S3 = Total Throughput of the line = 197469.668017 + 156168.655454 + 161044.475879 = 514682 (Bps) * 0.000008 = 4.12 Mbps

The following pseudo-code describes the algorithm of the test in more detail:

```
// Call the test download_test( target, 6500, '/1000MB.bin', 3 sec, 5
sec, 3 )

 // Define the test
function download_test( target, port, uri, warmupmaxtime,
 transfermaxtime,  numberofthreads ) {

   threads = array()    for i=0;
i<numberofthreads; i++ {

      t = new Thread( speedtest_thread( target, port, uri ) )
t.start()
      threads.put(t)
   }

   warmup_complete = false
warmup_bytes_transferred = 0
warmup_time_elapsed = 0   bytes_transferred
= 0
   time_elapsed = 0
   while( 1 ) {

      // Get latest statistics for each thread
foreach t in threads {

         // check to see if there's an error on the thread
if t.status = ERROR
            fail and exit with error status

         // Check to see if the warmup was not complete but now is
if (!warmup_complete) {            warmup_bytes_transferred +=
t.bytes_transferred            warmup_time_elapsed = now() -
t.time_start          }

         // Check to see if the test has completed
if (warmup_complete) {            bytes_transferred
+= t.bytes_transferred            time_elapsed =
now() - t.time_start
         }
      }

      // If warmup is now complete, mark it as such and begin testing
if (!warmup_complete &&
          (             warmup_time_elapsed >
warmupmaxtime)          ) {
      }

      // Check to see if we can finish
      if (warmup_complete) {

         // deduct warmup         bytes_transferred -
= warmup_bytes_transferred          time_elapsed -=
warmup_time_elapsed

// Check to see if we're done
         if ( time_elapsed > transfermaxtime ) {

            break;
         }
      }
   }

   // calculate final result
   speed = bytes_transferred / time_elapsed
}

// Multiple threads of the below will be called function
speedtest_thread( target, port, uri ) {
   bytes_transferred = 0
time_start = now()
   status = WAITING

   try{
      client = new http_client( target, port, uri )
status = CONNECTED      while( data =
client.recv() ) {
           bytes_transferred +=
data.length
      }    } catch {
status = ERRROR
   }
}
```

D. Latency and Packet Loss

The UDP Latency and Packet Loss tests measure the round-trip time of UDP packets for a fixed 5-second duration between the device and a target test site. Each 160-byte packet consists of an 8-byte sequence number and an 8-byte timestamp. If an acknowledgement is not received back within two seconds of sending, the packet is treated as lost. The test sends up to 200 packets (datagrams) and records the number of packets sent, the average round-trip time of responses, and the total number of packets lost.

The following pseudo-code describes the algorithm of the test in more detail:

```
call latencytest( server, 5000, 500ms, 2s, 200, 5s )

function latencytest ( host, port, interPacketTime, delayTimeout,
datagrams, maxTime ) {

   sent = 0
received = 0
lost = 0
rttArray = array()
start = now()

   sock = socket(host,port)    for
i = 0; i < datagrams; i++ {

      t1 = now()
send(sock, i)      sent++

      try {

         recv(i, delayTimeout )
t2 = now()         rtt = t2 -
t1         insert( rttArray,
rtt )         received++
      // ensures minimum spacing between packets is interPacketTime
sleep( max(0, interPacketTime - rtt) )

    } catch timeout {
lost++
    }

    // exit if we've exceeded maximum time
if start + maxTime > now() {      break
    }
  }

  // calculate average RTT, all other variables

  // are already available (sent, received, lost, etc)
  avgRtt = avg(rttArray)
}
```

E. Testing Schedule

The FCC Speed Test App for Android and iOS both enable a user to initiate “manual” tests. In addition, and unlike many commercially available speed tests which are solely user-initiated, the FCC Speed Test App for Android also contains a default setting which causes the App to execute at automated prescheduled test intervals.[6] The automated testing function can be disabled and the App can be configured to start a test only when manually executed. iOS devices do not have automated testing capability and can only execute the speed test manually. The scheduled testing approach minimizes extraneous factors that could degrade a statistically accurate measure of mobile broadband performance. Automatic background tests contribute valuable, high-quality data about mobile broadband performance.

It is possible to schedule tests to run with a fixed test frequency on Android. The test frequency is not exact, and the framework can decide to postpone the running of the tests especially for higher frequencies, or when the device is in the Doze mode (sleeping after a long period of inactivity).

The allowed frequencies are:

- Once every 24 hours
- Once every 12 hours
- Once every 6 hours
- Once an hour
- Every 15 mins

[6] The Apple iOS does not support features necessary for scheduled test execution on the App for iPhone and thus the App for iPhone only supports manual testing at this time.

It is possible to set constraints to stop running the tests unless some conditions are fulfilled. The possible constraints are:

- Wi-Fi only
- Allow while roaming
- Device idle
- Device charging

It is possible to enable/disable the showing of a notification with the results of the tests.

F. Test Server and Data Collection

The initial beta trials of the FCC Speed Test App and the analysis of the data collected by the various beta versions of the App ensured that once the App was officially launched, all collected data met the FCC's technical privacy and engineering requirements. In addition to data collected from active download speed, upload speed, latency, and packet loss tests, data related to the radio characteristics of the device, information about the handset type and operating system version, the GPS coordinates of the handset at the time each test is run (if available), the date and time of the observation, and other metrics are recorded on the handset in JSON (JavaScript Object Notation) nested data elements within flat files. These JSON files can be exported by the user and are transmitted to SamKnows[7] storage servers at periodic intervals after the completion of active test measurements.[8]

Once the JSON files are received by SamKnows, they are converted into row results that are inserted into a series of SQL tables using software developed by SamKnows, Inc. Each collection of results from a "test" share a primary key, which can be combined with local timestamp or metric values to combine the active and passive metrics that are connected during a single test. The Data Dictionaries for the JSON and CSV formats for Android and iOS describe in detail the nested format of the radio, handset, active test result, and other data recorded on the handset prior to transmission to the storage infrastructure, as well as the converted CSV table structures and data elements can be found on the Measuring Mobile Broadband website.[9]

All measurements are carried-out against any one of our U.S. StackPath test servers. Currently, these are:

[7] The FCC has contracted with a broadband measurement company, SamKnows, to help manage the program and conduct its technical functions. SamKnows performs functions such as writing and maintaining the software that performs the test measurements, responding to customer service requests, managing the App and the execution of tests, ensuring the integrity of and protecting the data, and providing analysis and support for the preparation of FCC reports. The terms of our contract with SamKnows include obligations to protect the data and your privacy.

[8] The tests results are transferred depending on the available connectivity at the conclusion of the test and can be stored and forwarded when connectivity is immediately unavailable.

[9] *See* https://www.fcc.gov/general/measuring-mobile-broadband-performance.

sp1-vm-atlanta-us.samknows.com
sp1-vm-chicago-us.samknows.com
sp1-vm-dallas-us.samknows.com
sp1-vm-losangeles-us.samknows.com
sp1-vm-sanjose-us.samknows.com
sp1-vm-seattle-us.samknows.com
sp1-vm-newyork-us.samknows.com
sp1-vm-ashburn-us.samknows.com
sp1-vm-miami-us.samknows.com
sp1-vm-denver-us.samknows.com
sp2-vm-chicago-us.samknows.com
sp2-vm-ashburn-us.samknows.com
sp2-vm-newyork-us.samknows.com

These servers are found in the **stackpath-us** target set, and are accessible via the Speedtest API at:

https://speedtest-api.samknows.com/targets?target_set=stackpath-us

Tests should be performed against the "nearest" test server. This server selection is determined at the start of each test sequence, and the same server should be used for all tests in that sequence. The nearest test server should be determined for Android by measuring the latency using the ICMP protocol or, in case this process fails, by TCP ping on port 6500. For iOS, the default latency measurement is done by TCP ping on port 6500. The server with the lowest latency or the lowest TCP connect time should be used for measurements.

1. Android Test Flow, Environmental Data, and JSON Format

In a scenario where all test types are switched to active on the app’s Test screen, upon pressing **Start Tests** the following sequence of actions takes place:

1. The app fetches the **stackpath-us** target set from the Speedtest API.
2. The server selection process (described above) is performed against each of the targets in the list.
3. The app downloads a file to “poke” the antenna and eventually triggers the switching to 5G.
4. Pause of 2 seconds.
5. The Download test is performed against the test server identified as the "nearest" test server for the user’s current location, from the previous step. The result and a snapshot of the current environmental data (see later) is captured.
6. Pause of 1750 milliseconds.
7. The Upload test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
8. Pause of 1750 milliseconds.

9. The latency/loss/jitter test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
10. Pause of 1750 milliseconds.
11. The results are submitted to the backend Data Ingestion API and a resulting Test ID is retrieved.
12. The results for the entire test sequence are paired with their respective Test ID and stored locally.

At the end of a test sequence, the following information is displayed to the user:

- Download speed
- Upload speed
- Latency
- Packet loss
- Jitter
- Date and time of measurement
- The Wi-Fi or cellular network that was tested
- The ISP that the user used
- The test server location

If any test fails to obtain a measurement for any reason (such as when there is no network connectivity at all), then “FAILED” is shown for the respective test result. If any other data was unavailable, due to a failure, then a "-" is shown in its place.

Table 1: Android Data Dictionary

The table below shows all the data fields that are collected during the tests. The fields with the name that starts with “beginning” or “end” are the fields that are reported twice for each test: one at the beginning of the test and one at the end.

The following is an exhaustive list of all possible fields that are reported by the app. However, not all of these fields will be present in every test. Their presence depends on device support and network support (for example, the base station ID is only returned on CDMA).

Please also note that some field names may differ in data exports from the backend database. The complete backend field names are provided in the “2021 FCC Mobile App Data Dictionary (Raw Data) - Android and iOS.xlsx.”

Common and environmental fields for Android	
Field name	**Description**
testId	Unique identifier for a test.
carrier_name	The mobile carrier as reported by the operating system.
iso_country_code	The ISO country code (e.g. "GB", "HK").
manufacturer	Manufacturer of the mobile phone.
mobile_country_code	Numeric mobile country code (e.g. 234 = UK).

mobile_network_code	Numeric mobile network code (e.g. 15 = Vodafone).
model	Model of the mobile phone.
operating_system_version	Operating system name and version.
version	App version number.
submission_type	Indicates whether test was executed manually by the user (“manual_test”) or run automatically (“scheduled_test”).
utc_date_time	UTC timestamp of when the full test cycle completed.
dhcp_dns1	Primary DNS server provided by DHCP.
dhcp_dns2	Secondary DNS server provided by DHCP.
dhcp_gateway	Default gateway IP provided by DHCP.
dhcp_ip_address	IP address provided by DHCP.
dhcp_lease_duration	DHCP lease duration.
dhcp_netmask	DHCP netmask.
dhcp_server_address	DHCP server.
{beginning/end}_cross_traffic_rx_avg_bps	The average volume of downstream cross-traffic at the start/end of the test, excluding test traffic.
{beginning/end}_cross_traffic_rx_peak_bps	The peak volume of downstream cross-traffic at the start/end of the test, excluding test traffic.
{beginning/end}_cross_traffic_tx_avg_bps	The average volume of upstream cross-traffic at the start/end of the test, excluding test traffic.
{beginning/end}_cross_traffic_tx_peak_bps	The peak volume of upstream cross-traffic during the test, excluding test traffic.
{beginning/end}_location_lat	Latitude at the start of measurement.
{beginning/end}_location_lon	Longitude at the start of measurement.
{beginning/end}_location_time	Android GPS location time.
{beginning/end}_memory_app_used	Memory used in MB by the app at the start/end of the test.
{beginning/end}_memory_device_free	Memory free on the device in MB at the start/end of the test.
{beginning/end}_memory_device_used	Memory used on the device in MB at the start/end of the test (not always available).
{beginning/end}_network_is_available	Is a network connection available at the start/end of the test.
{beginning/end}_network_is_connected	Is the device connected to a network at the start/end of the test.
{beginning/end}_network_is_connected_or_connecting	Is the device in a connecting state at the start/end of the test.
{beginning/end}_network_is_failover	Indicates whether the current connection resulted from the device failing over from a disconnect from a different network at the start/end of the test.
{beginning/end}_network_is_roaming	Indicates whether the cellular network the user is on is different to their home network (i.e. they are roaming).

{beginning/end}_network_state	Current connection state of the device at the start/end of the test. Enum (Associated, Associating, Authenticating, Completed, Disconnected, Dormant, Four Way Handshake, Group handshake, Inactive, Interface Disabled, Invalid, Scanning, Uninitalized).
{beginning/end}_network_subtype	The numeric network subtype code at the start/end of the test.
{beginning/end}_network_subtype_name	The cellular radio technology in use at the start/end of the test: Enum (1xRTT, CDMA, EDGE, GPRS, GSM, IDEN, EHRPD, EVDO-0, EVDO-A, EVDO-B, HSDPA, HSPA, HSPAP, HSUPA, IWLAN, TD-SCDMA, UMTS, LTE, UNKNOWN, NR).
{beginning/end}_network_type	Indicates whether the user is connected to mobile or mobile and Wi-Fi simultaneously, at the start/end of the test.
{beginning/end}_other_is_logged_in	Boolean indicating if the user is logged in to the app at the start/end of the test.
{beginning/end}_telephony_bandwidth	Array of cell bandwidths (kHz) for the current serving cells.
{beginning/end}_telephony_cellular_country_code	Mobile network-operator country code at the start/end of the test.
{beginning/end}_telephony_cellular_network_code	Mobile network-operator network code at the start/end of the test.
{beginning/end}_telephony_cell_signal_absolute_rf_channel_number	For NR New Radio Absolute Radio Frequency Channel Number at the start/end of the test. Integer value in range [0, 3279165] or {@code null} if not available.
{beginning/end}_telephony_cell_signal_asu	For WCDMA there is no standard definition of ASU. However, Android defines it as the the lesser of the following two results (for 1xRTT): RSSI Range (dBm): ASU Value -75..,16: -82..-76: 8 -90..-83: 4 -95..-91: 2 -100..-96: 1 ..-101: 99 Ec/Io Range (dB): ASU Value -90..: 16 -100..-91: 8 -115..-101: 4 -130..-116: 2 --150..-131: 1 ..-151: 99 For GSM the range is 0..31, 99

{beginning/end}_telephony_cell_signal_bands	Cellular signal bands.
{beginning/end}_telephony_cell_signal_carrier_aggregation	True if the cell is using carrier aggregation.
{beginning/end}_telephony_cell_signal_cell_connection	Cell connection status. This has the values: 0: No connection 1: Connected to primary serving cell 2: Connected to secondary serving cell 2147483647: Unknown
{beginning/end}_telephony_cell_signal_cell_identity	For NR the NR(New Radio 5G) Cell Identity. The 36-bit NR Cell Identity in range [0, 68719476735] or 0x7fffffffffffffffL if not available. For LTE 28-bit Cell Identity. For GSM 16-bit GSM Cell Identity described in TS 27.007, 0..65535.
{beginning/end}_telephony_cell_signal_mobile_country_code	Mobile Country Code at the start/end of the test as an integer or {@code null} if unknown.
{beginning/end}_telephony_cell_signal_mobile_network_code	Mobile Network Code at the start/end of the test as an integer or {@code null} if unknown.
{beginning/end}_telephony_cell_signal_network_type	One of the value "NR", "LTE", "WCDMA", "CDMA", "GSM".
{beginning/end}_telephony_cell_signal_physical_cell_identity	Physical cell ID at the start/end of the test.
	For LTE an integer value in range [0, 503].
	For NR an integer value in range [0, 1007].
{beginning/end}_telephony_cell_signal_rssi	Received Signal Strength Indication (RSSI) in dBm. For LTE the value range is [-113, -51] inclusively or CellInfo.UNAVAILABLE if unavailable. Reference: TS 27.007 8.5 Signal quality +CSQ. For GSM the value range is (-113, -51) or {@code null}.
{beginning/end}_telephony_cell_signal_signal_level	Signal strength level at the start/end of the test.
{beginning/end}_telephony_cell_signal_received_signal_power	For LTE the RSSNR at the start/end of the test if available or {@code null} if not available.
	For NR CSI reference 3GPP TS 38.215 Range: -140 dBm to -44 dBm or {@code null} if not available.
{beginning/end}_telephony_cell_signal_received_signal_quality	For LTE RSRQ if available or {@code null} if unavailable. For NR CSI reference signal received quality at the start/end of the test. Ref 3GPP TS 38.215. Range: -20 dB to -3 dB or {@code null} if not available.
{beginning/end}_telephony_cell_signal_signal_strength	Signal strength as dBm.
{beginning/end}_telephony_cell_signal_timing_advance	For LTE timing advance value, as a value in range of 0..1282. {@code null} is reported when there is no active RRC connection.

	Refer to 3GPP 36.213 Sec 4.2.3.
	For GSM timing advance between 0..219 symbols (normally 0..63). {@code null} is reported when there is no RR connection. Refer to 3GPP 45.010 Sec 5.8.
{beginning/end}_telephony_cell_signal_tracking_area_code	Tracking area code at the start/end of the test. 16 bit integer or {@code null} if not available.
{beginning/end}_telephony_cell_signal_base_station_identity_code	The base station identity code (CDMA only).
{beginning/end}_telephony_cell_signal_location_area_code	The cellular location area code.
{beginning/end}_telephony_cellular_operator_name	Alphabetic name of current registered operator at the start/end of the test. Availability: Only when user is registered to a network. Result may be unreliable on CDMA networks.
{beginning/end}_telephony_cell_strength_asu	RSSI in ASU as reported by the cell strength. Asu is calculated based on 3GPP RSSI. Refer to 3GPP 27.007 (Ver 10.3.0) Sec 8.69 0..31, 99 or {@code null}.
{beginning/end}_telephony_cell_strength_network_type	Network type from the signal strength.
{beginning/end}_telephony_cell_strength_signal_level	Signal strength level at the start/end of the test.
{beginning/end}_telephony_cell_strength_received_signal_power	For LTE the RSSNR at the start/end of the test if available or {@code null} if not available.
	For NR reference 3GPP TS 38.215 Range: -140 dBm to -44 dBm or {@code null} if not available.
{beginning/end}_telephony_cell_strength_received_signal_quality	Reference signal received quality.
	For NR CSI reference signal received quality at the start/end of the test. Ref 3GPP TS 38.215. Range: -20 dB to -3 dB or {@code null} if not available.
{beginning/end}_telephony_cell_strength_signal_strength	The cellular signal strength at the start/end of the test.
	For NR CSI-RSRP as dBm value -140...-44dBm or {@code null} if not available.
{beginning/end}_telephony_cell_strength_received_signal_noise_ratio	Reference signal signal-to-noise ratio or {@code null} if not available.
	For NR Reference: 3GPP TS 38.215 Sec 5.1.*, 3GPP TS 38.133 10.1.16.1 Range: -23 dB to 23 dB.
{beginning/end}_wifi_frequency	The Wi-Fi network frequency in MHz at the start/end of the test.
{beginning/end}_wifi_hidden_ssid	Boolean indicating whether the SSID the user is connected to is hidden at the start/end of the test.
{beginning/end}_wifi_link_speed	The Wi-Fi link speed in Mbit/s at the start/end of the test.
{beginning/end}_wifi_network_id	The ID number that the supplicant uses to identify this network configuration entry at the start/end of the test.

{beginning/end}_wifi_rssi	The receive signal strength of the Wi-Fi network at the start/end of the test.
{beginning/end}_wifi_supplicant_state	Whether or not the Wi-Fi supplicant completed or not at the start/end of the test.
{beginning/end}_telephony_telephony_display_info_network_type	Network type as reported by the Telephony Display Info.
{beginning/end}_telephony_telephony_display_info_override_network_type	Network subtype as reported by the Telephony Display Info.
{beginning/end}_telephony_cellular_technology	The cellular radio technology generation at the start/end of the test. Enum 2g, 3g, 4g, 5g, simless.
{beginning/end}_telephony_connection_type	Primary field indicating whether the user is on cellular or Wi-Fi at the start/end of the test. Enum: cell, wi-fi.
{beginning/end}_telephony_sim_country_code	The SIM country code at the start/end of the test (note that this can differ to the mobile_country_code above if the user is roaming).
{beginning/end}_telephony_sim_network_code	The SIM network code at the start/end of the test (note that this can differ to the mobile_network_code above if the user is roaming).
{beginning/end}_telephony_sim_operator_name	The SIM operator name at the start/end of the test (note that this can differ to the carrier_name above if the user is roaming).

Download and upload speed test fields for Android

Field name	Description
utc_datetime	Date time of the test in the format "2021-10-26T14:54:12Z".
local_datetime	Date time of the test in the format "2021-10-26T15:54:12+01:00" (called “dtime” in the backend database).
target	The test server in use.
duration	Duration of the test, in microseconds.
thread_count	The number of concurrent TCP connections used in the test.
warmup_duration	Time consumed for all the TCP streams to arrive at optimal window size (units: microseconds).
warmup_bytes	Bytes transferred for all the TCP streams during the warm-up phase.
bytes_transferred	Bytes transferred during the measurement phase.
bytes_sec	The measured speed, in bytes per second. Multiply by 0.000008 to convert to Mbit/s (only present in the backend database).
throughput	The measured speed, in bytes per second. Multiply by 0.000008 to convert to Mbit/s (same as bytes_sec field).
successes	Number of successes (always 1 or 0).
failures	Number of failures (always 1 or 0).

Latency, packet loss, and jitter test fields for Android

Field name	Description
utc_datetime	Date time of the test in the format "2021-10-26T14:54:12Z".
local_datetime	Date time of the test in the format "2021-10-26T15:54:12+01:00" (called “dtime” in the backend database).
target	The test server in use.
duration	Duration of the test, in microseconds.
packet_size	Size of packets used in the test (bytes).
stream_bits_per_sec	The bits per second of the transmitted stream.
packets_sent	Number of packets sent during test.
packets_received	Number of packets received during test.
jitter	Calculated variation in latency between packets flowing between device and server (microseconds).
round_trip_time	Round trip time in microseconds.
mean_opinion_score	Mean Opinion Score (MOS) during the latency test.
status_code	Internal enum indicating the status of the test (0 is success).
successes	Number of successes (always 1 or 0).
failures	Number of failures (always 1 or 0).

JSON Local Data Export Example for Android

Results are serialized into the following JSON format for the local data export functionality. Please note that not all fields from the table above will be present in every local data export. Fields may be excluded based upon device or network support.

The JSON format for submissions made to the backend database differ by one JSON object: an outermost object is introduced to indicate that the data belongs to the FCC panel and that the submission is anonymized. Given that the structure is almost identical to the one below, an example has been omitted from this document for the sake of brevity.

```
{
  "version": "2.0.4058",
  "carrier_name": "",
  "iso_country_code": "GB",
  "manufacturer": "Samsung",
  "mobile_country_code": "234",
  "mobile_network_code": "20",
  "model": "SM-N950F",
  "operating_system_version": "Android 9",
  "tests": {
    "download": {
      "bytes_transferred": 13617918,
      "duration": 4994819,
      "environment": {
        "beginning": {
          "cross_traffic": {
```

```
      "rx_avg_bps": 6062510,
      "rx_peak_bps": 6062510,
      "tx_avg_bps": 97004,
      "tx_peak_bps": 97004
    },
    "dhcp": {
      "dns1": "192.168.1.254",
      "dns2": "0.0.0.0",
      "gateway": "192.168.1.254",
      "ip_address": "192.168.1.99",
      "lease_duration": 86400,
      "netmask": "0.0.0.0",
      "server_address": "192.168.1.254"
    },
    "location": {
      "lat": 51.5081773,
      "lon": 0.0191087,
      "time": "2021-10-26T14:54:12+0000"
    },
    "memory": {
      "app_used": 9,
      "device_free": 1786,
      "device_used": 3553
    },
    "network": {
      "is_roaming": false,
      "subtype_name": "",
      "type": "mobile_wifi"
    },
    "telephony": {
      "bandwidth": "",
      "cellular_country_code": "234",
      "cellular_network_code": "10",
      "cell_signal": {
        "absolute_rf_channel_number": 115,
        "asu": 31,
        "base_station_identity_code": 2,
        "carrier_aggregation": false,
        "cell_connection": 0,
        "cell_identity_id": 13874,
        "location_area_code": 21212,
        "mobile_country_code": 234,
        "mobile_network_code": 10,
        "network_type": "GSM",
        "signal_level": 4,
        "signal_strength": -51,
        "timing_advance": 0
      },
      "cellular_operator_name": "",
      "cellular_technology": "simless",
      "connection_type": "wi-fi",
      "sim_country_code": "234",
      "sim_network_code": "20",
      "sim_operator_name": ""
    },
    "wifi": {
      "frequency": 2462,
      "hidden_ssid": false,
      "link_speed": 173,
        "network_id": 9,
        "rssi": -37,
        "supplicant_state": "completed"
      }
    },
    "end": {
      "cross_traffic": {
        "rx_avg_bps": 841037,
        "rx_peak_bps": 6062510,
        "tx_avg_bps": 1028820,
        "tx_peak_bps": 1755556
      },
      "dhcp": {
        "dns1": "192.168.1.254",
        "dns2": "0.0.0.0",
        "gateway": "192.168.1.254",
        "ip_address": "192.168.1.99",
        "lease_duration": 86400,
        "netmask": "0.0.0.0",
        "server_address": "192.168.1.254"
      },
      "location": {
        "lat": 51.5081807,
        "lon": 0.0191033,
        "time": "2021-10-26T14:54:33+0000"
      },
      "memory": {
        "app_used": 11,
        "device_free": 1894,
        "device_used": 3445
      },
      "network": {
        "is_roaming": false,
        "subtype_name": "",
        "type": "mobile_wifi"
      },
      "telephony": {
        "bandwidth": "",
        "cellular_country_code": "234",
        "cellular_network_code": "10",
        "cell_signal": {
          "absolute_rf_channel_number": 115,
          "asu": 31,
          "base_station_identity_code": 2,
          "carrier_aggregation": false,
          "cell_connection": 0,
          "cell_identity_id": 13874,
          "location_area_code": 21212,
          "mobile_country_code": 234,
          "mobile_network_code": 10,
          "network_type": "GSM",
          "signal_level": 4,
          "signal_strength": -51,
          "timing_advance": 0
        },
        "cellular_operator_name": "",
        "cellular_technology": "simless",
        "connection_type": "wi-fi",
        "sim_country_code": "234",
            "sim_network_code": "20",
            "sim_operator_name": ""
          },
          "wifi": {
            "frequency": 2462,
            "hidden_ssid": false,
            "link_speed": 173,
            "network_id": 9,
            "rssi": -37,
            "supplicant_state": "completed"
          }
        }
      },
      "failures": 0,
      "local_datetime": "2021-10-26T15:54:25+01:00",
      "successes": 1,
      "target": "sp2-vm-ashburn-us.samknows.com",
      "thread_count": 3,
      "throughput": 2726408,
      "utc_datetime": "2021-10-26T14:54:25Z",
      "warmup_bytes": 1749000,
      "warmup_duration": 3005245
    },
    "latency": {
      "duration": 5065802,
      "environment": {
        "beginning": {
          "cross_traffic": {
            "rx_avg_bps": 8174878,
            "rx_peak_bps": 8174878,
            "tx_avg_bps": 171343,
            "tx_peak_bps": 171343
          },
          "dhcp": {
            "dns1": "192.168.1.254",
            "dns2": "0.0.0.0",
            "gateway": "192.168.1.254",
            "ip_address": "192.168.1.99",
            "lease_duration": 86400,
            "netmask": "0.0.0.0",
            "server_address": "192.168.1.254"
          },
          "location": {
            "lat": 51.5081716,
            "lon": 0.0191263,
            "time": "2021-10-26T14:54:04+0000"
          },
          "memory": {
            "app_used": 8,
            "device_free": 1821,
            "device_used": 3518
          },
          "network": {
            "is_roaming": false,
            "subtype_name": "",
            "type": "mobile_wifi"
          },
          "telephony": {
            "bandwidth": "",
      "cellular_country_code": "234",
      "cellular_network_code": "10",
      "cell_signal": {
        "absolute_rf_channel_number": 115,
        "asu": 31,
        "base_station_identity_code": 2,
        "carrier_aggregation": false,
        "cell_connection": 0,
        "cell_identity_id": 13874,
        "location_area_code": 21212,
        "mobile_country_code": 234,
        "mobile_network_code": 10,
        "network_type": "GSM",
        "signal_level": 4,
        "signal_strength": -51,
        "timing_advance": 0
      },
      "cellular_operator_name": "",
      "cellular_technology": "simless",
      "connection_type": "wi-fi",
      "sim_country_code": "234",
      "sim_network_code": "20",
      "sim_operator_name": ""
    },
    "wifi": {
      "frequency": 2462,
      "hidden_ssid": false,
      "link_speed": 173,
      "network_id": 9,
      "rssi": -37,
      "supplicant_state": "completed"
    }
  },
  "end": {
    "cross_traffic": {
      "rx_avg_bps": 5820067,
      "rx_peak_bps": 8174878,
      "tx_avg_bps": 105017,
      "tx_peak_bps": 171343
    },
    "dhcp": {
      "dns1": "192.168.1.254",
      "dns2": "0.0.0.0",
      "gateway": "192.168.1.254",
      "ip_address": "192.168.1.99",
      "lease_duration": 86400,
      "netmask": "0.0.0.0",
      "server_address": "192.168.1.254"
    },
    "location": {
      "lat": 51.5081773,
      "lon": 0.0191087,
      "time": "2021-10-26T14:54:12+0000"
    },
    "memory": {
      "app_used": 9,
      "device_free": 1790,
      "device_used": 3549
    },
        "network": {
          "is_roaming": false,
          "subtype_name": "",
          "type": "mobile_wifi"
        },
        "telephony": {
          "bandwidth": "",
          "cellular_country_code": "234",
          "cellular_network_code": "10",
          "cell_signal": {
            "absolute_rf_channel_number": 115,
            "asu": 31,
            "base_station_identity_code": 2,
            "carrier_aggregation": false,
            "cell_connection": 0,
            "cell_identity_id": 13874,
            "location_area_code": 21212,
            "mobile_country_code": 234,
            "mobile_network_code": 10,
            "network_type": "GSM",
            "signal_level": 4,
            "signal_strength": -51,
            "timing_advance": 0
          },
          "cellular_operator_name": "",
          "cellular_technology": "simless",
          "connection_type": "wi-fi",
          "sim_country_code": "234",
          "sim_network_code": "20",
          "sim_operator_name": ""
        },
        "wifi": {
          "frequency": 2462,
          "hidden_ssid": false,
          "link_speed": 173,
          "network_id": 9,
          "rssi": -37,
          "supplicant_state": "completed"
        }
      }
    },
    "failures": 0,
    "jitter": 15098,
    "local_datetime": "2021-10-26T15:54:12+01:00",
    "mean_opinion_score": 1,
    "packet_size": 160,
    "packets_received": 200,
    "packets_sent": 200,
    "round_trip_time": 146558,
    "status_code": 0,
    "stream_bits_per_sec": 51200,
    "successes": 1,
    "target": "sp2-vm-ashburn-us.samknows.com",
    "utc_datetime": "2021-10-26T14:54:12Z"
  },
  "testId": "1635597254",
  "upload": {
    "bytes_transferred": 5776536,
    "duration": 5000122,
    "environment": {
      "beginning": {
        "cross_traffic": {
          "rx_avg_bps": 28797,
          "rx_peak_bps": 28797,
          "tx_avg_bps": 879401,
          "tx_peak_bps": 879401
        },
        "dhcp": {
          "dns1": "192.168.1.254",
          "dns2": "0.0.0.0",
          "gateway": "192.168.1.254",
          "ip_address": "192.168.1.99",
          "lease_duration": 86400,
          "netmask": "0.0.0.0",
          "server_address": "192.168.1.254"
        },
        "location": {
          "lat": 51.5081807,
          "lon": 0.0191033,
          "time": "2021-10-26T14:54:33+0000"
        },
        "memory": {
          "app_used": 6,
          "device_free": 1897,
          "device_used": 3442
        },
        "network": {
          "is_roaming": false,
          "subtype_name": "",
          "type": "mobile_wifi"
        },
        "telephony": {
          "bandwidth": "",
          "cellular_country_code": "234",
          "cellular_network_code": "10",
          "cell_signal": {
            "absolute_rf_channel_number": 115,
            "asu": 31,
            "base_station_identity_code": 2,
            "carrier_aggregation": false,
            "cell_connection": 0,
            "cell_identity_id": 13874,
            "location_area_code": 21212,
            "mobile_country_code": 234,
            "mobile_network_code": 10,
            "network_type": "GSM",
            "signal_level": 4,
            "signal_strength": -51,
            "timing_advance": 0
          },
          "cellular_operator_name": "",
          "cellular_technology": "simless",
          "connection_type": "wi-fi",
          "sim_country_code": "234",
          "sim_network_code": "20",
          "sim_operator_name": ""
        },
        "wifi": {
```

```
      "frequency": 2462,
      "hidden_ssid": false,
      "link_speed": 173,
      "network_id": 9,
      "rssi": -37,
      "supplicant_state": "completed"
    }
  },
  "end": {
    "cross_traffic": {
      "rx_avg_bps": 27939,
      "rx_peak_bps": 190818,
      "tx_avg_bps": 153122,
      "tx_peak_bps": 879401
    },
    "dhcp": {
      "dns1": "192.168.1.254",
      "dns2": "0.0.0.0",
      "gateway": "192.168.1.254",
      "ip_address": "192.168.1.99",
      "lease_duration": 86400,
      "netmask": "0.0.0.0",
      "server_address": "192.168.1.254"
    },
    "location": {
      "lat": 51.5081771,
      "lon": 0.0191134,
      "time": "2021-10-26T14:54:43+0000"
    },
    "memory": {
      "app_used": 7,
      "device_free": 1915,
      "device_used": 3424
    },
    "network": {
      "is_roaming": false,
      "subtype_name": "",
      "type": "mobile_wifi"
    },
    "telephony": {
      "bandwidth": "",
      "cellular_country_code": "234",
      "cellular_network_code": "10",
      "cell_signal": {
        "absolute_rf_channel_number": 115,
        "asu": 31,
        "base_station_identity_code": 2,
        "carrier_aggregation": false,
        "cell_connection": 0,
        "cell_identity_id": 13874,
        "location_area_code": 21212,
        "mobile_country_code": 234,
        "mobile_network_code": 10,
        "network_type": "GSM",
        "signal_level": 4,
        "signal_strength": -51,
        "timing_advance": 0
      },
      "cellular_operator_name": "",
            "cellular_technology": "simless",
            "connection_type": "wi-fi",
            "sim_country_code": "234",
            "sim_network_code": "20",
            "sim_operator_name": ""
          },
          "wifi": {
            "frequency": 2462,
            "hidden_ssid": false,
            "link_speed": 173,
            "network_id": 9,
            "rssi": -37,
            "supplicant_state": "completed"
          }
        }
      },
      "failures": 0,
      "local_datetime": "2021-10-26T15:54:44+01:00",
      "successes": 1,
      "target": "sp2-vm-ashburn-us.samknows.com",
      "thread_count": 3,
      "throughput": 1155279,
      "utc_datetime": "2021-10-26T14:54:44Z",
      "warmup_bytes": 2857512,
      "warmup_duration": 3000075
    }
  },
  "submission_type": "scheduled_test",
  "utc_date_time": "2021-10-26T14:54:45Z"
}
```

2. iOS Test Flow, Environmental Data, and JSON Format

In a scenario where all test types are switched to active on the app’s Test screen, upon pressing **Start Tests** the following sequence of actions takes place:

1. The app fetches the **stackpath-us** target set from the Speedtest API.
2. The server selection process (described above) is performed against each of the targets in the list.
3. The Download test is performed against the test server identified to have the lowest TCP connection time for the user’s current location, from the previous step. The result and a snapshot of the current environmental data (see later) is captured.
4. Pause of 2 seconds.
5. The Upload test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
6. Pause of 2 seconds.
7. The latency/loss/jitter test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
8. Pause of 2 seconds.
9. The results are submitted to the backend Data Ingestion API and a resulting Test ID is retrieved.

10. The results for the entire test sequence are paired with their respective Test ID and stored locally.

At the end of a test sequence, the following information is displayed to the user:

- Download speed
- Upload speed
- Latency
- Packet loss
- Jitter
- Date and time of measurement
- The Wi-Fi or cellular network that was tested
- The ISP that the user used
- The test server location

If any test fails to obtain a measurement for any reason (such as when there is no network connectivity at all), then "FAILED" is shown for the respective test result. If any other data was unavailable, due to a failure, then a "-" is shown in its place.

Table 2: iOS Data Dictionary

The table below shows all the data fields that are collected during the tests.

The iOS device's JSON data export feature within the app generates different field names and data structures from the JSON submission that is sent to the backend. The field names that are sent to the backend are listed in the first column, whilst the field names used in the device JSON export are listed in the second column. Future versions of the app will unify these.

Please also note that some JSON field names may differ from the backend database. The complete backend field names are provided in the "2021 FCC Mobile App Data Dictionary (Raw Data) - Android and iOS.xlsx."

Common and environmental fields for iOS		
Backend submission JSON field name	**Device JSON export field name**	**Description**
panelId	-	Internal SamKnows identifier for assigning the information to the correct backend client panel (always a value of 293 for the FCC).
anonymised	-	Boolean that indicates whether the user's Personal Identifiable Information is redacted.
version	-	The schema version for the JSON submission (this is not the same as app_version).

data.tests.<TEST>.environment.location.lat	tests.<TEST>.latitude	Latitude at the start of measurement.
data.tests.<TEST>.environment.location.lon	tests.<TEST>.longitude	Longitude at the start of measurement.
data.tests.<TEST>.environment.location.accuracy.vertical	-	Vertical accuracy at the start of measurement.
data.tests.<TEST>.environment.location.accuracy.horizontal	-	Horizontal accuracy at the start of measurement.
data.tests.<TEST>.environment.location.address	-	Approximate postal address at the start of measurement.
data.tests.<TEST>.environment.memory.app_used	-	Memory used in MB by the app at the start of the test.
data.tests.<TEST>.environment.memory.device_free	-	Memory free on the device in MB at the start of the test.
data.tests.<TEST>.environment.memory.device_used	-	Memory used on the device in MB at the start of the test (not always available).
data.tests.<TEST>.environment.wifi.ssid	-	The SSID of the router that was used to perform the test if over WiFi.
data.tests.<TEST>.environment.network.subtype_name	-	The cellular radio technology in use at the start of the test: Enum (1xRTT, CDMA, EDGE, GPRS, GSM, IDEN, EHRPD, EVDO-0, EVDO-A, EVDO-B, HSDPA, HSPA, HSPAP, HSUPA, IWLAN, TD-SCDMA, UMTS, LTE, UNKNOWN, NR).
data.tests.<TEST>.environment.telephony.cellular_technology	-	The generation of cellular radio technology (Enum 2g, 3g, 4g, 5g, simless).
data.tests.<TEST>.environment.telephony.connection_type	-	Primary field indicating whether the user is on cellular or WiFi (Enum: cell, wi-fi).
data.tests.<TEST>.environment.other.is_logged_in	-	Boolean indicating if the user is logged in to the app at the start of the test.
data.device_environment.id	-	Platform-specific unique identifier for the device. Generated randomly upon every test for the FCC (so it's not a persistent unique identifier for the device).
data.device_environment.mobile_network_code	-	Mobile network code for the SIM card in the device, in its numeric representation. If multiple SIMs are present, this will be the active one.

data.device_environment.mobile_country_code	-	Mobile country code for the SIM card in the device, in its numeric representation. If multiple SIMs are present, this will be the active one.
data.device_environment.carrier_name	device_environment.carrier_name	The mobile carrier for the device's active SIM card for data, as reported by the operating system. Reports no_cellular if on WiFi.
data.device_environment.iso_country_code	-	The ISO country code (e.g. "gb", hk").
data.device_environment.manufacturer	device_environment.manufacturer	Manufacturer of the mobile phone (always has a value of Apple).
data.device_environment.model	device_environment.model	Model of the mobile phone (e.g. iPhone 12,1).
data.device_environment.operating_system_version	device_environment.operating_system_version	Operating system name and version (e.g. iOS 15.2).
data.metadata.app_version	metadata.app_version	App version & build number (e.g. v4.1.4 b3).
Download and upload speed test fields for iOS		
Backend submission JSON field name	**Device JSON export field name**	**Description**
data.tests.<TEST>.utc_datetime	tests.<TEST>.utc_datetime	Date time of the locale time-zone in the format "2021-10-26T14:54:12Z".
data.tests.<TEST>.local_datetime	tests.<TEST>.local_datetime	Date time of the locale time-zone in the format "2021-10-26T15:54:12+01:00".
data.tests.<TEST>.successes	tests.<TEST>.success	Number of successes (always 1 or 0).
data.tests.<TEST>.failures	-	Number of failures (always 1 or 0).
data.tests.<TEST>.duration	-	Duration of the test, in microseconds.
data.tests.<TEST>.target	-	The test server in use.
data.tests.<TEST>.thread_count	-	The number of concurrent TCP connections used in the test.
data.tests.<TEST>.warmup_duration	-	Time consumed for all the TCP streams to arrive at optimal window size (units: microseconds).
data.tests.<TEST>.warmup_bytes	-	Number of bytes transferred during the warmup phase of the speed tests.
data.tests.<TEST>.bytes_transferred	-	Total bytes transferred during the measurement phase.
data.tests.<TEST>.throughput	tests.<TEST>.testResult	The resulting throughput of the speed test.

-	tests.<TEST>.testProvider	A lookup of the public IP address against the Maxmind database. Never submitted with the JSON submission. Same as the maxmind_isp value in the backend database. Obtained on the device using the https://speedtest-api.samknows.com/isp api call.
-	tests.<TEST>.isWiFi	Boolean value which indicates if the test was performed over Wifi.
-	tests.<TEST>.testNetwork	The mobile network for the device’s active SIM card for data (e.g. "vodafone UK (4G)"). If on WiFi, this value will contain the the WiFi SSID.
-	tests.<TEST>.referenceNumber	The testID for this test sequence.
-	tests.<TEST>.timestamp	The numerical timestamp of the test time (e.g. 1634661555.4815311).
-	tests.<TEST>.testServer	The location name of the test server.
-	tests.<TEST>.testIndex	The index of the test.

Latency, packet loss, and jitter test fields for iOS

Backend submission JSON field name	Device JSON export field name	Description
data.tests.<TEST>.utc_datetime	tests.<TEST>.utc_datetime	Date time of the locale time-zone in the format "2021-10-26T14:54:12Z".
data.tests.<TEST>.local_datetime	tests.<TEST>.local_datetime	Date time of the locale time-zone in the format "2021-10-26T15:54:12+01:00".
data.tests.<TEST>.successes	tests.<TEST>.success	Number of successes (always 1 or 0).
data.tests.<TEST>.failures	-	Number of failures (always 1 or 0).
data.tests.<TEST>.duration	-	Duration of the test, in microseconds.
data.tests.<TEST>.target	-	The test server in use.
data.tests.<TEST>.packet_size	-	Size of packets used in the latency test (bytes).
data.tests.<TEST>.stream_bits_per_second	-	The measured speed, in bits per second.
data.tests.<TEST>.packets_sent	-	Number of packets sent during latency test.
data.tests.<TEST>.packets_received	-	Number of packets received during latency test.
data.tests.<TEST>.round_trip_time	tests.Latency.testResult	Round trip time in the latency test.

		In the backend submission JSON this is reported in microseconds, whilst in the device export JSON it is reported in milliseconds.
data.tests.<TEST>.jitter	tests.Latency.Jitter.testResult	Calculated variation in latency between packets flowing between device and server in the latency test. In the backend submission JSON this is reported in microseconds, whilst in the device export JSON it is reported in milliseconds.
data.tests.<TEST>.status_code	-	Internal code to denote the resulting status of the latency test (Defaults to 0 meaning NO_ERROR).
data.tests.<TEST>.mean_opinion_score	-	An estimate of perceived connection quality, factoring-in aspects such as latency, packet loss and jitter.
-	tests.Latency.PacketLoss.testResult	Packet loss percentage.
-	tests.<TEST>.testProvider	A lookup of the public IP address against the Maxmind database. Never submitted with the JSON submission. Same as the maxmind_isp value in the backend database. Obtained on the device using the https://speedtest-api.samknows.com/isp api call.
-	tests.<TEST>.isWiFi	Boolean value which indicates if the test was performed over Wifi.
-	tests.<TEST>.testNetwork	The mobile network for the device's active SIM card for data (e.g. "vodafone UK (4G)"). If on WiFi, this value will contain the the WiFi SSID.
-	tests.<TEST>.referenceNumber	The testID for this test sequence.
-	tests.<TEST>.timestamp	The numerical timestamp of the test time (e.g. 1634661555.4815311).
-	tests.<TEST>.testServer	The location name of the test server.
-	tests.<TEST>.testIndex	The index of the test.

JSON Reporting Format Example for iOS

Results are serialized into the following JSON format when transmitting them to the backend database.

```
{
  "anonymised": true,
  "panelId": 253,
  "version": 1,
  "data": {
    "device_environment": {
      "mobile_network_code": "15",
      "mobile_country_code": "234",
      "operating_system_version": "iOS 14.4",
      "model": "iPhone13,3",
      "iso_country_code": "gb",
      "manufacturer": "Apple",
      "id": "94F90F11-B7C0-4EC6-BC30-C5601B970E64",
      "carrier_name": "vodafone UK"
    },
    "metadata": {
      "app_version": "v4.1.4 b3"
    },
    "tests": {
      "latency": {
        "packets_received": 200,
        "utc_datetime": "2021-03-05T13:22:46Z",
        "target": "sp1-vm-chicago-us.samknows.com",
        "local_datetime": "2021-03-05T13:22:46Z",
        "duration": 5000355,
        "environment": {
          "other": {
            "is_logged_in": false
          },
          "network": {
            "subtype_name": "LTE"
          },
          "telephony": {
            "connection_type": "wi-fi",
            "cellular_technology": "4g"
          },
          "memory": {
            "device_used": 0,
            "app_used": 144,
            "device_free": 399277
          },
          "wifi": {
            "ssid": ""
          },
          "location": {
            "lat": 51.495334211107462,
            "address": "Building XX, YY Road, ZZ11 1XY",
            "accuracy": {
              "horizontal": 65,
              "vertical": 10
            },
            "lon": 0.073787086332168406
          }
        },
      "status_code": 0,
      "stream_bits_per_sec": 51200,
      "failures": 0,
      "packet_size": 160,
      "packets_sent": 200,
      "jitter": 932,
      "mean_opinion_score": 1,
      "round_trip_time": 93911,
      "successes": 1
    },
    "download": {
      "warmup_bytes": 9460368,
      "warmup_duration": 3000181,
      "bytes_transferred": 19393056,
      "throughput": 3878241,
      "successes": 1,
      "failures": 0,
      "utc_datetime": "2021-03-05T13:22:32Z",
      "environment": {
        "telephony": {
          "cellular_technology": "4g",
          "connection_type": "wi-fi"
        },
        "location": {
          "accuracy": {
            "vertical": 10,
            "horizontal": 65
          },
          "lat": 51.495334211107462,
          "lon": 0.073787086332168406,
          "address": "Building XX, YY Road, ZZ11 1XY"
        },
        "memory": {
          "device_used": 0,
          "app_used": 144,
          "device_free": 399278
        },
        "other": {
          "is_logged_in": false
        },
        "network": {
          "subtype_name": "LTE"
        },
        "wifi": {
          "ssid": ""
        }
      },
      "thread_count": 3,
      "duration": 5000476,
      "local_datetime": "2021-03-05T13:22:32Z",
      "target": "sp1-vm-chicago-us.samknows.com"
    },
    "upload": {
      "target": "sp1-vm-chicago-us.samknows.com",
      "thread_count": 3,
      "bytes_transferred": 7045920,
      "warmup_duration": 3000042,
      "environment": {
        "network": {
            "subtype_name": "LTE"
          },
          "wifi": {
            "ssid": ""
          },
          "telephony": {
            "cellular_technology": "4g",
            "connection_type": "wi-fi"
          },
          "memory": {
            "device_used": 0,
            "app_used": 144,
            "device_free": 399277
          },
          "location": {
            "lon": 0.073787086332168406,
            "lat": 51.495334211107462,
            "address": "Building XX, YY Road, ZZ11 1XY",
            "accuracy": {
              "horizontal": 65,
              "vertical": 10
            }
          },
          "other": {
            "is_logged_in": false
          }
        },
        "utc_datetime": "2021-03-05T13:22:40Z",
        "successes": 1,
        "local_datetime": "2021-03-05T13:22:40Z",
        "failures": 0,
        "duration": 5000047,
        "throughput": 1409170,
        "warmup_bytes": 6346920
      }
    }
  }
}
```

JSON Local Data Export Example for iOS

Results are serialized into the following JSON format when exporting them using the device's local data export functionality:

```
{
  "tests" : {
    "Upload" : {
      "local_datetime" : "2021-09-21T12:06:47+01:00",
      "referenceNumber" : "3046270262",
      "testIndex" : 0,
      "latitude" : 51.495279410522393,
      "testServer" : "Ashburn, US",
      "timestamp" : 1632222413.0320759,
      "testProvider" : "Vodafone UK",
      "testNetwork" : "HomeHub",
      "longitude" : 0.073730860056579903,
      "utc_datetime" : "2021-09-21T11:06:47Z",
      "testResult" : 15.746728721313875,
      "isWiFi" : true,
      "success" : true
    },
    "Download" : {
      "testProvider" : "Vodafone UK",
      "testIndex" : 0,
      "utc_datetime" : "2021-09-21T11:06:39Z",
      "local_datetime" : "2021-09-21T12:06:39+01:00",
      "testServer" : "Ashburn, US",
      "latitude" : 51.495279410522393,
      "success" : true,
      "longitude" : 0.073730860056579903,
      "timestamp" : 1632222413.032166,
      "testResult" : 70.013874046316829,
      "testNetwork" : "HomeHub",
      "isWiFi" : true,
      "referenceNumber" : "3046270262"
    },
    "Latency" : {
      "timestamp" : 1632222413.0321879,
      "referenceNumber" : "3046270262",
      "testProvider" : "Vodafone UK",
      "testNetwork" : "HomeHub",
      "testResult" : 83.165214285714285,
      "latitude" : 51.495279410522393,
      "success" : true,
      "PacketLoss" : {
        "latitude" : 51.495279410522393,
        "testServer" : "Ashburn, US",
        "testProvider" : "Vodafone UK",
        "testResult" : 0,
        "isWiFi" : true,
        "timestamp" : 1632222413.0322151,
        "longitude" : 0.073730860056579903,
        "referenceNumber" : "3046270262",
        "local_datetime" : "2021-09-21T12:06:52+01:00",
        "utc_datetime" : "2021-09-21T11:06:52Z",
        "testNetwork" : "HomeHub",
        "success" : true,
        "testIndex" : 0
      },
      "testServer" : "Ashburn, US",
      "longitude" : 0.073730860056579903,
      "local_datetime" : "2021-09-21T12:06:52+01:00",
      "utc_datetime" : "2021-09-21T11:06:52Z",
      "isWiFi" : true,
      "testIndex" : 0,
      "Jitter" : {
        "local_datetime" : "2021-09-21T12:06:52+01:00",
        "testIndex" : 0,
        "latitude" : 51.495279410522393,
        "isWiFi" : true,
        "longitude" : 0.073730860056579903,
        "success" : true,
        "utc_datetime" : "2021-09-21T11:06:52Z",
        "testProvider" : "Vodafone UK",
        "referenceNumber" : "3046270262",
        "testResult" : 1.4590000000000001,
        "testServer" : "Ashburn, US",
        "timestamp" : 1632222413.032203,
        "testNetwork" : "HomeHub"
      }
    }
  },
  "metadata" : {
    "app_version" : "v4.2.0 b1"
  },
  "device_environment" : {
    "operating_system" : "iOS",
    "model" : "iPhone13,3",
    "os_version" : "15.0",
    "operating_system_version" : "iOS 15.0",
    "manufacturer" : "Apple",
    "carrier_name" : "vodafone UK"
  }
}
```

III. FCC Speed Test App Privacy Notice and Terms of Use (updated May 13, 2021)[10]

A. What Information We Collect

The information the FCC Speed Test App ("App") collects is limited to information used to measure your mobile (including WiFi-enabled) broadband service. We do not collect personally identifiable information, such as name, phone number, location, or identifiers associated with your device, without your permission. We collect five kinds of information to measure the performance of your mobile broadband service.

1. Location (with your permission)

If enabled, the App will report your network name and your physical location when using the App.

- When using the App, you will be prompted to select whether the App may access location information only when using the App, always, or never.
- You do not need to grant access to location information to use the App, but you will be unable to view a map of your historical tests or have your results included in a map created by the FCC to study mobile broadband access if you do not.
- Without the location data, the measurement results will be of limited usefulness to the FCC in its studies of mobile broadband service. When possible, we will aggregate your location data with other users' location information to provide aggregated network performance and coverage statistics.

[10] For the most recent update, *see* https://www.fcc.gov/general/mobile-broadband-performance-application-privacy-notice-and-terms-use.

2. Time of Data Collection

The App will report the date and time when it performs measurements of your broadband performance. Date and time are important metrics to capture because network loading, which affects performance, can vary across times of the day and/or days of the week. Time zone is an important metric to capture as it allows the comparison of measurements against known outages.

3. Device Type and Operating System Version

The App reports the manufacturer and model of the device you are using, as well as the version of the operating system installed on your device.

4. Mobile Wireless Network Performance and Characteristics

The App will report information about your mobile device connection performance, such as your service provider, the strength and quality of the radio signal, and the type of connection.

5. Broadband Performance

When not connected to WiFi, the App tests and reports your mobile broadband upload and download rates, round trip latency, and packet loss measured between your device and the servers managed by the FCC's contractor and other project partners.

If you are connected to WiFi, the App will test and report the performance of your connection through your WiFi network, which performance will depend upon, but is not limited to, your WiFi configuration, your mobile device operating system and performance, the exact location of the mobile device (including the proximity of the device to the WiFi access point), the number of devices sharing your WiFi bandwidth, and the performance of your fixed internet service. This data is stored on your device for you to review, and periodically is uploaded to our servers automatically. You can find more detail in the FCC's technical summary of this program at https://www.fcc.gov/measuring-broadband-america/mobile/technical-summary.html.

B. Data Sharing

The data the App reports is helpful for consumers, the FCC, and others interested in understanding broadband in the United States. We share broadband performance information collected through the App in four ways.

1. Internally

We may share your information within the FCC to write various reports on mobile broadband performance and to support our development of broadband policy.

2. Third-Party Partners Who Help Us Run Our Test and Support Our Program

We share your mobile broadband performance information with our contractor who manages the measurement program, with partners who support the program and architecture, and with partners supporting our analysis or contributing peer reviews. We share data subject to agreements that include strict requirements to safeguard the data, not disclose the data, and use data only in furtherance of the goals of the program.

The FCC has contracted with a broadband measurement company, SamKnows, to help manage the program and conduct its technical functions. SamKnows performs functions such as writing and maintaining the software that performs the test measurements, responding to customer service requests, managing the App and the execution of tests, ensuring the integrity of and protecting the data, and providing analysis and support for the preparation of FCC reports. The terms of our contract with SamKnows include obligations to protect the data and your privacy.

Research platforms and your carrier may support various aspects of the testing and architecture for the program. We may share your detailed mobile performance data with these partners supporting our data processing and analysis for the specific purpose of identifying patterns in the data and recommending ways of addressing any concerns for your privacy and anonymity. The FCC directs researchers, its contractor, and your carrier working under non-disclosure agreements (NDA) to analyze the collected data for privacy risks or concerns and to plan for future measurement efforts.

3. Pursuant to Legitimate Requests by Law Enforcement or Where Otherwise Required by Law or Regulation

We may share broadband performance data collected by this App subject to legitimate, written requests by law enforcement or where otherwise required by law or regulation.

4. De-Identified Data Available to the Public

We will publish de-identified data in summary statistics, coarsened data, the creation of maps, and other minimally necessary datasets that support our review of the statistics only if we determine that the data poses very low risks to your privacy. These include:

a. **Summary Data**
We will publish averages and other summary statistics that describe important features of broadband performance. These summary statistics pose very low risks to your privacy.

b. **Coarsened Data**
We will publish only de-identified data in a coarsened form that supports the averages and other statistics that we publish in our reports. Prior to release of this data, the FCC will consider the likelihood that the data could be combined with other datasets to identify individual users of the App and make adjustments to minimize the risk of identification.

c. **Creation of Maps**
The FCC will use de-identified data to create maps that reflect the general location, time, and results of the tests to inform the public on the availability of broadband and the FCC in its efforts to improve broadband mapping and access to broadband. If possible, your test results will be aggregated with the results of other tests conducted nearby to minimize the risk of identification.

C. Data Consumption

By default, the App is configured to use no more than 100 megabytes (MB) of data each month for automated testing. Any additional tests you initiate will also consume between 100 kilobytes (kB) for the smallest packet loss test and 40 MB for a complete suite of tests. At any time, you can change the amount of data the App uses by increasing or reducing the “monthly data cap” in the Settings menu. You should ensure that your monthly broadband usage, including the data used by the App, does not exceed the data allowance included in your mobile broadband package. Your carrier may charge you for any data used in excess of your package’s data allowance.

D. Stopping Your Participation

If at any time you want to stop participating in this program, simply delete the App, and the App will not collect any additional data. Any data collected prior to the deletion of the App will remain in the data sets subject to the above terms and protections.

E. Other Terms of Use of the Application

- Detailed Testing Architecture and Technical Summary (https://www.fcc.gov/measuring-broadband-america/mobile/technical-summary.html)
- Program Stakeholders' Code of Conduct (https://www.fcc.gov/measuring-broadband-america/mobile/code-of-conduct.html)
- GNU Licensing Agreement (http://www.gnu.org/licenses/gpl-2.0.html)
- This PRA Collection Authorized By OMB Control No. 3060-1139 (Expires 01/31/2024). Paperwork Reduction Act (PRA) of 1995 Notice (https://www.fcc.gov/measuring-broadband-america/mobile/pra-privacy-act-notice.html)
- Mobile Provider Disclaimers (https://www.fcc.gov/measuring-broadband-america/mobile/mobile-provider-disclaimers.html)
- Mobile broadband providers endorse some applications certified for use on their network. This application may not have been formally certified by your provider or carry a formal endorsement from your mobile broadband network

[DOCUMENT ENDS]