2022 FCC Speed Test App Technical Description

Office of Engineering and Technology
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I. Introduction

The FCC Speed Test app ("the App")[1] is a free mobile device application available to the public for testing the performance of consumer subscription cellular mobile services and wireless access to in-home broadband networks. The App also can be opted in to automatically submit speed test results to the FCC to support the Broadband Data Collection[2] and Measuring Broadband America[3] programs. The programs collect consumers' *crowdsourced* speed test and network performance *challenge* data to help inform the FCC's efforts to provide improved mobile wireless broadband network coverage information to the public.

This technical description document for the App provides detailed information on the metrics and methodologies used to conduct connection performance tests on mobile broadband networks. Specifically, this document reviews the measurement techniques; the test sequence and testing methods for download, upload, latency, pack loss, and jitter; environmental data collection for Android and iOS operating systems; data reporting features; and an overview of the backend test system architecture.

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 wireless broadband network performance.[4]

A. FCC Speed Test Methodology Overview

The App's technologies and methodologies are developed collaboratively with a technical solutions contractor, SamKnows, Inc.[5] 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 allow for access to many of the radio parameters that the FCC

[1] The FCC Speed Test app is available for 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] *See generally* https://www.fcc.gov/BroadbandData.
[3] *See generally* https://www.fcc.gov/general/measuring-broadband-america.
[4] This 2022 Technical Description updates the earlier 2016, 2018, and 2021 versions to describe the FCC Speed Test app currently in use.
[5] *See generally* https://www.samknows.com/.

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 app.

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 on 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.[6] 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

[6] 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. 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.

between the mobile broadband provider's network, and the network on which the chosen measurement server resides.

2. Performance Testing and 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

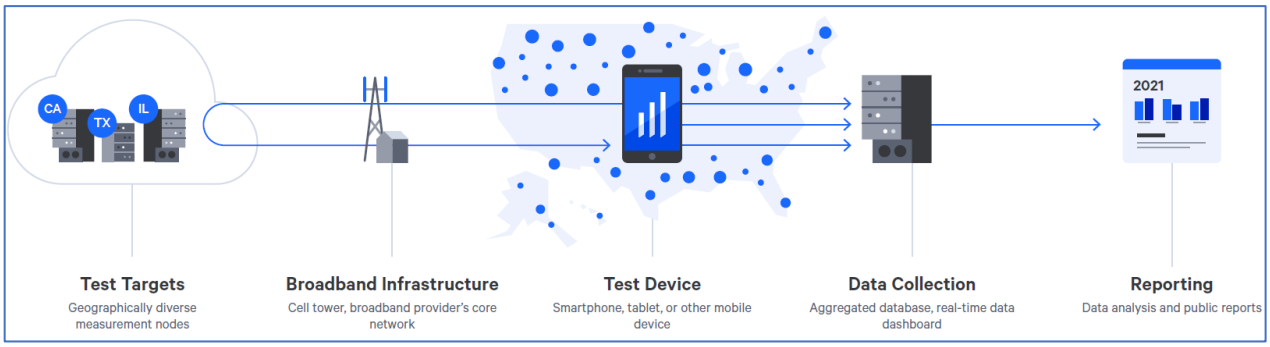
The test system architecture focuses on measuring the performance of mobile broadband networks. The measurement servers are located across the U.S., which are hosted by a major content delivery network (CDN) with servers in proximity at multiple Internet exchange points/peering locations for unbiased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



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. Test Scheduler

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.[7] 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).

[7] The Apple iOS does not support features necessary for scheduled test execution on the App; the App for iOS devices only supports manual testing at this time.

The allowed frequencies are:

1. Once an hour
2. Once every 6 hours
3. Once every 12 hours
4. Once every 24 hours

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

- Wi-Fi only
- 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[8] storage servers at periodic intervals after the completion of active test measurements.[9]

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

[8] 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.

[9] 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.

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.[10]

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

sp1-bdc-atlanta-us.samknows.com
sp1-bdc-chicago-us.samknows.com
sp1-bdc-dallas-us.samknows.com
sp1-bdc-losangeles-us.samknows.com
sp1-bdc-sanjose-us.samknows.com
sp1-bdc-seattle-us.samknows.com
sp1-bdc-newyork-us.samknows.com
sp1-bdc-ashburn-us.samknows.com
sp1-bdc-miami-us.samknows.com
sp1-bdc-denver-us.samknows.com
sp2-bdc-chicago-us.samknows.com
sp2-bdc-ashburn-us.samknows.com
sp2-bdc-newyork-us.samknows.com
sp2-bdc-seattle-us.samknows.com
n1-bdc-hawaii-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.

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

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

After a user has navigated through the required user journey and upon initiating a test the following sequence of actions takes place:

- The app fetches the **stackpath-us** target set from the Speedtest API.
- The server selection process (described above) is performed against each of the targets in the list.
- The app downloads a file to "poke" the antenna and eventually triggers the switching to 5G.
- Pause of 2 seconds.
- 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.
- Pause of 1750 milliseconds.
- The Upload test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
- Pause of 1750 milliseconds.
- 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.
- Pause of 1750 milliseconds.
- The results are submitted to the backend Data Ingestion API and a resulting Test ID is retrieved.
- 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:

a. Download speed (Mbps)
b. Upload speed (Mbps)
c. Latency (ms)
d. Packet loss (%)
e. Jitter (ms)
f. Test ID (Provided there was successful submission of test results and thus a Test ID received back)
g. Connection Type (Indicates either the name of the wireless network that was tested if tests were purely conducted over cellular or indicates a Wi-Fi connection with the SSID if tests were conducted over Wi-Fi at any point in the test sequence)

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.

If the same above test results are viewed inside the Test History section, the following additional Test Details are also displayed;

h. Coordinates (The latitude and longitude of the location where the test took place)
i. Test Server (The location of the test server)
j. Tested By (The name of the individual who conducted the test, if a name was supplied by the user)
k. Date (The date and time of measurement)

Table 1: Android Data Dictionary

The set of tables below define a collective list of all the data fields that are both collected during the tests and the fields that are generated server-side. A small subset of fields which purely only feature as part of the submission from the Android app to the backend ingest are also listed for completeness.

The table below lists all possible fields that are reported by the Android app to the SamKnows backend ingest.

Field Name	Description
submission_category	The category of the data submission. This represents an enumerated value and must be one of the following; **Consumer Crowdsourced** | **Consumer Challenge** | **Entity Crowsourced** | **Entity Challenge** | **Provider Response** | **Other**
name	The full name of the user
email	The email address of the user. Value must match valid email address format eg. **user@domain.tld**
phone	The phone number of the user. Value must match valid US phone number format eg. **000-0000-0000** . This value may be *null* of the *submission_category* is one of the following; *Consumer Crowdsourced* | *Entity Crowsourced* | *Provider Response* | *Other*
device_timestamp	The timestamp of the moment at which the test submission to the backend is first attempted. This is measured by the device and adheres to the ISO-8601 format which includes seconds and time zone offset eg. **YYYY-MM-DD[T]hh:mm:ss±hh:mm**
device_imei	The International Mobile Equipment Identity (IMEI) of the device. Value corresponds to a valid 15-digit IMEI. The value may be null if the *submission_category* value is *Consumer Crowdsourced, Entity Crowsourced, Consumer Challenge, Provider Response or Other*
device_type	Indicates the type of device used. This represents an enumerated value and must be one of the following; **iOS | Android | Other**
manufacturer	The name of the manufacturer of the device eg. **Google**
model	The name of the device model eg. **PIXEL 6**

Field Name	Description
operating_system	Name and version of the device's operating system eg. **Android 12**
device_tac	The 8-digit Type Allocation Code (TAC) of the device eg. **35142059** . The value may be null if the app does not have requisite permissions or the device does not return a valid device TAC
device_id	A unique device identifier generated by the app on the device, on an individual app-installtion basis eg. **a255e318-df8d-46d1-a23b-9589e4d2e53e** . If anonymisation is true however, this device identifier is re-generated randomly for each submission to further promote privacy.
app_name	The name of the mobile speed test app. In the case of the BDC app, this is always **FCC Speed Test App**
app_version	The version of the mobile speed test app eg. **v4.3.0 b14**
provider_name	The name of the mobile service provider eg. **T-Mobile**
sim_mobile_country_code	The mobile country code of mobile service provider reported for the active SIM card in the device eg. **310**
sim_mobile_network_code	The mobile network code of mobile service provider reported for the active SIM card in the device eg. **260**
net_mobile_country_code	The mobile country code of mobile service provider reported from the connected network eg. **310**
net_mobile_network_code	The mobile network code of mobile service provider reported from the connected network eg. **260**
in_vehicle_flag	Indicates whether the test was conducted while in-vehicle or outdoors.
external_antenna_flag	Indicates whether an in-vehicle test was conducted with an antenna external to the vehicle. Note that when *in_vehicle_flag* is false, this value must also be *false*
scheduled_test_flag	Indicates whether the test was automated/scheduled or whether it was user-initiated manually.
timestamp	The timestamp of the moment at which the connection for a test metric was initialized or when a respective value or set of values were captured. This is measured by the device and adheres to the ISO-8601 format which includes seconds and time zone offset eg. **YYYY-MM-DD[T]hh:mm:ss±hh:mm**
warmup_duration	The duration that the connection took to stabilize before the test metric commenced. Applies to only the Download and Upload tests.
warmup_bytes_transferred	The total amount of data that was transferred during the period the connection took to stabilize before the test metric commenced. Applies to only the Download and Upload tests.
duration	The duration that the test metric took to complete.
bytes_transferred	The total amount of data that the test metric transferred. Applies to only the Download and Upload tests.

Field Name	Description
bytes_sec	The number of bytes per second that the test metric transferred. Also known as *Throughput*. Applies to only the Download and Upload tests.
targets	An array of hostnames/IP addresses of the targets servers used for conducting the test metric against. Eg. **["sp2-vm-ashburn-us.samknows.com"]** .
success_flag	Indicates whether the test completed successfully, without a change in state or connectivity.
carrier_aggregation_flag	Indicates whether the network used carrier aggregation during the test metric. This value may be null for 3G tests. This value may also be null if the device does not return a valid value or a value of *Unknown*
network_connected_flag	Indicates whether the network is connected.
network_available_flag	Indicates whether the network is available.
network_roaming_flag	Indicates whether the network is roaming.
round_trip_time	The round-trip latency. This value only applies to the Latency test.
jitter	Calculated variation in latency between packets flowing between device and server. This value only applies to the Latency test.
packets_sent	The number of packets sent during the test. This value only applies to the Latency test. The full amount of packets sent by the BDC app is **200**
packets_received	The number of packets received during the test. This value only applies to the Latency test.
latitude	The unprojected (WGS-84) geographic coordinate latitude of the reported location where the test was conducted.
longitude	The unprojected (WGS-84) geographic coordinate longitude of the reported location where the test was conducted.
horizontal_accuracy	The horizontal accuracy of the location coordinates radially, measured from the device. The value may also be null if the device does not return a valid value.
speed	The speed of the device at the time test was conducted. The value may be null if a valid value cannot be obtained at the time of measurement. The value may also be null if the submission_category is either Consumer Crowsourced, Entity Crowdsourced or Other
speed_accuracy	The speed accuracy of the device at the time the test was conducted. The value may be null if a valid value cannot be obtained at the time of measurement. The value may also be null if the device does not return a valid value.
cell_id	The measured mobile broadcast cell identifier. This value may be null if the device does not return a valid value or returns a value of *Unknown*
physical_cell_id	The measured physical cell identity (PCI) of the cell. This value is *null* for tests conducted over 3G. This value may also be null if the device does not return a valid value or returns a value of Unknown
cell_connection	The connection status of the cell. The value is either **0**, **1** or **2** 0 - Not Serving, 1 - Primary Serving, 2 - Secondary Serving. This value may be null if the device does not return a valid value or returns a value of Unknown

Field Name	Description
network_generation	The network generation of the cell. The value is always one of the following; **2G** | **3G** | **4G** | **5G** | **Other**
network_subtype	The network subtype of the cell. The value is always one of the following; **1X | EVDO | WCDMA | GSM | HSPA | HSPA+ | LTE | NRSA | NRNSA**
signal_strength	The measured signal strength of the cell. This value may be *null* if the device does not return a valid value or returns a value of *Unknown*. This value represents the Received Signal Strength Indication (RSSI) for 3G tests or the Reference Signal Received Power (RSRP) for 4G LTE or 5G NR cells.
rssi	The measured Received Signal Strength Indication (RSSI) of the cell. This value may be null for 5G cells. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
rsrp	The measured Reference Signal Received Power (RSRP) of the cell. This value is null for 3G cells. This value represents the Synchronization Signal (SS) for 5G NR cells or the Channel-specific Reference Signal (CRS) for 4G LTE cells.
rsrq	The measured Reference Signal Received Quality (RSRQ) of the cell. This value is null for 3G cells. This value represents the Synchronization Signal (SS) for 5G NR cells or the Channel-specific Reference Signal (CRS) for 4G LTE cells.
sinr	The measured Signal to Interference and Noise Ratio (SINR) of the cell. This value is null for 3G cells. This value represents the Synchronization Signal (SS) for 5G NR cells or the Channel-specific Reference Signal (CRS) for 4G LTE cells.
csi_rsrp	The measured 5G Channel State Information (CSI) RSRP of the cell. This value is null for 3G or 4G LTE cells. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
csi_rsrq	The measured 5G Channel State Information (CSI) RSRQ of the cell. This value is null for 3G or 4G LTE cells. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
csi_sinr	The measured 5G Channel State Information (CSI) SINR of the cell. This value is null for 3G or 4G LTE cells. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
cqi	The measured Channel Quality Indicator (CQI) of the cell. This value is null for 3G cells. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
spectrum_band	The spectrum band used by the cell. This value may be null for 3G cells. This value may also be null if the device does not return a valid value or returns a value of Unknown. The reported band value corresponds to the Operating Bands tables; 4G LTE: 3GPP TS 36.101 section 5 | 5G-NR: 3GPP TS 38.101 table 5.2-1
spectrum_bandwidth	The total amount of spectrum bandwidth used by the cell. This value may also be null if the device does not return a valid value or returns a value of *Unknown*
arfcn	The measured absolute physical RF channel number of the cell. This value may also be null if the device does not return a valid value or returns a value of *Unknown*

The following fields are generated server-side and are also present in the data transferred from the SamKnows backend to the BDC backend. They are also present in the local device export data.

Field Name	Description
test_id	The unique identifier used by the app or entity to differentiate tests.
server_timestamp	The timestamp measured by the server of the moment at which the test submission data was received by the app's servers
server_source_port	The source TCP port of the device submitting test submission data, measured by the server
server_source_ip_address	The source IP address of the device submitting test submission data, measured by the server

The following additional fields are only submitted by the Android app to the SamKnows ingest and are not relevant and therefore not present in the data transferred to the BDC backend or the local device export.

Field Name	Description
agentId	A unique identifier originally generated by the SamKnows backend and returned to the app when the initial registration call is made. Eg **b264f318-df8d-46d1-a23b-9589e4d2e53e** This identifier is generated on an initial registration basis for each app and linked to a panel.
anonymised	Indicates to the ingest whether the device_id is persistent. If anonymised is true, each device_id is never linked to more than one set of results, to ensure greater privacy. For the BDC apps this always has a value of **false**
version	The version of the JSON schema. For the BDC apps this always has a value of **2**
connection_type	Indicates the type of connection over which the test was conducted. Always has one of two possible values; **cell** or **wi-fi**

The comprehensive list of field names described in the tables above, along with additional information is also provided separately, in the accompanying Data Dictionary files.

FCC BDC App 2022 - Data Dictionary (Apps to SK Backend).xlsx
FCC BDC App 2022 - Data Dictionary (SK Backend to BDC Backend).xlsx
FCC BDC App 2022 - Data Dictionary (Device Export).xlsx

JSON Reporting Format Example for Android

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


```
{
  "anonymised": false,
  "agentId": "89c96256-44c1-4384-8ace-246a4cfa2b0e",
  "source_name": "FCC BDC App",
  "version": 2,
  "body": {
    "submission_category": "Consumer Challenge",
    "contact": {
      "name": "John Doe",
      "email": "john.doe@gmail.com",
      "phone": "002346762534"
    },
    "submissions": [
      {
        "test_id": "123456789",
        "device_timestamp": "2022-01-20T00:00:00+00:00",
        "server_timestamp": "2022-01-20T00:00:35+00:00",
        "server_source_ip_address": "172.58.189.166",
        "server_source_port": 3743,
        "device_imei": "490154647216475",
                "device_type": "Android",
        "manufacturer": "Samsung",
        "model": "SM-G998U",
        "operating_system": "Android 12.0",
        "device_tac": "99001200",
        "device_id": "28a24540-56f8-4384-8ace-246a4cfa2b0e",
        "app_name": "FCC Speed Test app",
        "app_version": "4.2.2",
        "provider_name": "T-Mobile",
        "sim_mobile_country_code": "310",
        "sim_mobile_network_code": "260",
        "net_mobile_country_code": "310",
        "net_mobile_network_code": "260",
        "in_vehicle_flag": false,
        "external_antenna_flag": false,
        "scheduled_test_flag": false,
        "tests": {
          "download": {
            "timestamp": "2022-01-20T00:00:02+00:00",
            "warmup_duration": 3001787,
            "warmup_bytes_transferred": 36031636,
            "duration": 5000802,
            "bytes_transferred": 67948392,
            "bytes_sec": 19487461,
            "locations": [
              {
                "timestamp": "2022-01-20T00:00:02+00:00",
                "latitude": 36.1835702,
                "longitude": -78.3661906,
                "horizontal_accuracy": 65,
                "speed": 6.5,
                "speed_accuracy": 1.0
              },
```

```
  {
    "timestamp": "2022-01-20T00:00:10+00:00",
    "latitude": 36.1835702,
    "longitude": -78.3661906,
    "horizontal_accuracy": 65,
    "speed": 6.5,
    "speed_accuracy": 1.0
  }
],
"cells": [
                    {
    "timestamp": "2022-01-20T00:00:02+00:00",
    "cell_id": 32193025,
    "physical_cell_id": 191,
    "cell_connection": 1,
    "network_generation": "4G",
    "network_subtype": "LTE",
    "signal_strength": -95,
    "rssi": -105,
    "rsrp": -103,
    "rsrq": -12,
    "sinr": 2,
    "csi_rsrp": -103,
    "csi_rsrq": -12,
    "csi_sinr": 2,
    "cqi": 11,
    "spectrum_band": "66",
    "spectrum_bandwidth": 15.0,
    "arfcn": 66786
  },
                    {
    "timestamp": "2022-01-20T00:00:02+00:00",
    "cell_id": 32193026,
    "physical_cell_id": 192,
    "cell_connection": 2,
    "network_generation": "4G",
    "network_subtype": "LTE",
    "signal_strength": -95,
    "rssi": -105,
    "rsrp": -103,
    "rsrq": -12,
    "sinr": 2,
    "csi_rsrp": -103,
    "csi_rsrq": -12,
    "csi_sinr": 2,
    "cqi": 11,
    "spectrum_band": "66",
    "spectrum_bandwidth": 15.0,
    "arfcn": 66786
                    },
                    {
    "timestamp": "2022-01-20T00:00:02+00:00",
    "cell_id": 32193027,
    "physical_cell_id": 193,
    "cell_connection": 2,
    "network_generation": "4G",
    "network_subtype": "LTE",
    "signal_strength": -95,
    "rssi": -105,
    "rsrp": -103,
```

```
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:10+00:00",
  "cell_id": 32193025,
  "physical_cell_id": 191,
  "cell_connection": 1,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:10+00:00",
  "cell_id": 32193026,
  "physical_cell_id": 192,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:10+00:00",
  "cell_id": 32193027,
  "physical_cell_id": 193,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
```

```
      "rsrq": -12,
      "sinr": 2,
      "csi_rsrp": -103,
      "csi_rsrq": -12,
      "csi_sinr": 2,
      "cqi": 11,
      "spectrum_band": "66",
      "spectrum_bandwidth": 15.0,
      "arfcn": 66786
    }
  ],
  "targets": ["sp1-vm-ashburn-us.samknows.com"],
  "success_flag": true,
  "carrier_aggregation_flag": false,
  "network_connected_flag": true,
  "network_available_flag": true,
  "network_roaming_flag": false,
                "connection_type": "cell"
},
        "upload": {
  "timestamp": "2022-01-20T00:00:12+00:00",
  "warmup_duration": 3001787,
  "warmup_bytes_transferred": 36031636,
  "duration": 5000105,
  "bytes_transferred": 7775576,
  "bytes_sec": 1555082,
  "locations": [
    {
      "timestamp": "2022-01-20T00:00:12+00:00",
      "latitude": 36.1835702,
      "longitude": -78.3661906,
      "horizontal_accuracy": 65,
      "speed": 6.5,
      "speed_accuracy": 1.0
    },
    {
      "timestamp": "2022-01-20T00:00:20+00:00",
      "latitude": 36.1835702,
      "longitude": -78.3661906,
      "horizontal_accuracy": 65,
      "speed": 6.5,
      "speed_accuracy": 1.0
    }
  ],
  "cells": [
                  {
      "timestamp": "2022-01-20T00:00:12+00:00",
      "cell_id": 32193025,
      "physical_cell_id": 191,
      "cell_connection": 1,
      "network_generation": "4G",
      "network_subtype": "LTE",
      "signal_strength": -95,
      "rssi": -105,
      "rsrp": -103,
      "rsrq": -12,
      "sinr": 2,
      "csi_rsrp": -103,
      "csi_rsrq": -12,
      "csi_sinr": 2,
```

```
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
                {
  "timestamp": "2022-01-20T00:00:12+00:00",
  "cell_id": 32193026,
  "physical_cell_id": 192,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
                },
                {
  "timestamp": "2022-01-20T00:00:12+00:00",
  "cell_id": 32193027,
  "physical_cell_id": 193,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:20+00:00",
  "cell_id": 32193025,
  "physical_cell_id": 191,
  "cell_connection": 1,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
```

```
      "cqi": 11,
      "spectrum_band": "66",
      "spectrum_bandwidth": 15.0,
      "arfcn": 66786
    },
    {
      "timestamp": "2022-01-20T00:00:20+00:00",
      "cell_id": 32193026,
      "physical_cell_id": 192,
      "cell_connection": 2,
      "network_generation": "4G",
      "network_subtype": "LTE",
      "signal_strength": -95,
      "rssi": -105,
      "rsrp": -103,
      "rsrq": -12,
      "sinr": 2,
      "csi_rsrp": -103,
      "csi_rsrq": -12,
      "csi_sinr": 2,
      "cqi": 11,
      "spectrum_band": "66",
      "spectrum_bandwidth": 15.0,
      "arfcn": 66786
    },
    {
      "timestamp": "2022-01-20T00:00:20+00:00",
      "cell_id": 32193027,
      "physical_cell_id": 193,
      "cell_connection": 2,
      "network_generation": "4G",
      "network_subtype": "LTE",
      "signal_strength": -95,
      "rssi": -105,
      "rsrp": -103,
      "rsrq": -12,
      "sinr": 2,
      "csi_rsrp": -103,
      "csi_rsrq": -12,
      "csi_sinr": 2,
      "cqi": 11,
      "spectrum_band": "66",
      "spectrum_bandwidth": 15.0,
      "arfcn": 66786
    }
  ],
  "targets": ["sp1-vm-ashburn-us.samknows.com"],
  "success_flag": true,
                "carrier_aggregation_flag": false,
  "network_connected_flag": true,
  "network_available_flag": true,
  "network_roaming_flag": false,
                "connection_type": "cell"
},
"latency": {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "duration": 5129955,
  "round_trip_time": 40915,
  "jitter": 7611,
  "packets_sent": 200,
```

```
"packets_received": 200,
"locations": [
 {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "latitude": 36.1835702,
  "longitude": -78.3661906,
  "horizontal_accuracy": 65,
  "speed": 6.5,
  "speed_accuracy": 1.0
 },
 {
  "timestamp": "2022-01-20T00:00:30+00:00",
  "latitude": 36.1835702,
  "longitude": -78.3661906,
  "horizontal_accuracy": 65,
  "speed": 6.5,
  "speed_accuracy": 1.0
 }
],
"cells": [
 {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "cell_id": 32193025,
  "physical_cell_id": 191,
  "cell_connection": 1,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
 },
                    {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "cell_id": 32193026,
  "physical_cell_id": 192,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
                    },
```

```
                {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "cell_id": 32193027,
  "physical_cell_id": 193,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:30+00:00",
  "cell_id": 32193025,
  "physical_cell_id": 191,
  "cell_connection": 1,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
{
  "timestamp": "2022-01-20T00:00:30+00:00",
  "cell_id": 32193026,
  "physical_cell_id": 192,
  "cell_connection": 2,
  "network_generation": "4G",
  "network_subtype": "LTE",
  "signal_strength": -95,
  "rssi": -105,
  "rsrp": -103,
  "rsrq": -12,
  "sinr": 2,
  "csi_rsrp": -103,
  "csi_rsrq": -12,
  "csi_sinr": 2,
  "cqi": 11,
  "spectrum_band": "66",
  "spectrum_bandwidth": 15.0,
  "arfcn": 66786
},
```

```
          {
            "timestamp": "2022-01-20T00:00:30+00:00",
            "cell_id": 32193027,
            "physical_cell_id": 193,
            "cell_connection": 2,
            "network_generation": "4G",
            "network_subtype": "LTE",
            "signal_strength": -95,
            "rssi": -105,
            "rsrp": -103,
            "rsrq": -12,
            "sinr": 2,
            "csi_rsrp": -103,
            "csi_rsrq": -12,
            "csi_sinr": 2,
            "cqi": 11,
            "spectrum_band": "66",
            "spectrum_bandwidth": 15.0,
            "arfcn": 66786
          }
         ],
         "targets": ["sp1-vm-ashburn-us.samknows.com"],
         "success_flag": true,
         "carrier_aggregation_flag": false,
         "network_connected_flag": true,
         "network_available_flag": true,
         "network_roaming_flag": false,
                        "connection_type": "cell"
       }
      }
     }
   ]
  }
}
```


JSON Local Data Export Example for Android

Results are serialized into the following JSON format for the local data export functionality.


```
{
  "contact" : {
    "name" : "John Doe",
    "email" : "john.doe@gmail.com",
    "phone" : "123-456-7890"
  },
  "submissions" : [ {
    "model" : "SM-G955U1",
    "tests" : {
      "upload" : {
        "cells" : [ {
          "cqi" : null,
          "rsrp" : -104,
          "rsrq" : -20,
          "rssi" : null,
          "sinr" : null,
          "arfcn" : 323,
          "cell_id" : null,
          "csi_rsrp" : null,
```

```
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:04:53+00:00",
    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -104,
    "physical_cell_id" : 299,
    "network_generation" : "4G",
    "spectrum_bandwidth" : null
  }, {
    "cqi" : null,
    "rsrp" : -100,
    "rsrq" : -15,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:04:53+00:00",
    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -100,
    "physical_cell_id" : 117,
    "network_generation" : "4G",
    "spectrum_bandwidth" : null
  }, {
    "cqi" : null,
    "rsrp" : -103,
    "rsrq" : -20,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:04:53+00:00",
    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -103,
    "physical_cell_id" : 28,
    "network_generation" : "4G",
    "spectrum_bandwidth" : null
  }, {
    "cqi" : null,
    "rsrp" : -94,
    "rsrq" : -15,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : 106766,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:04:53+00:00",
```

```
  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -94,
  "physical_cell_id" : 204,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
  "cqi" : null,
  "rsrp" : -104,
  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:05+00:00",
  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -104,
  "physical_cell_id" : 299,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
  "cqi" : null,
  "rsrp" : -103,
  "rsrq" : -16,
  "rssi" : null,
  "sinr" : null,
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  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "rsrq" : -15,
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  "sinr" : null,
  "arfcn" : 323,
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  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "spectrum_band" : "",
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  "signal_strength" : -95,
  "physical_cell_id" : 204,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
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  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:05+00:00",
  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -102,
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  "network_generation" : "4G",
  "spectrum_bandwidth" : null
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  "cqi" : null,
  "rsrp" : -104,
  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:05+00:00",
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```
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   } ],
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   "duration" : 5000049,
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   "locations" : [ {
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    "latitude" : 51.4952354,
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    "longitude" : 0.0739316,
    "timestamp" : "2022-10-31T13:17:48+00:00",
    "speed_accuracy" : 0.22022715,
    "horizontal_accuracy" : 5
   } ],
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   "network_available_flag" : true,
   "network_connected_flag" : true,
   "carrier_aggregation_flag" : false,
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    "rsrq" : -20,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
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    "csi_rsrq" : null,
    "csi_sinr" : null,
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    "rsrq" : -16,
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    "sinr" : null,
    "arfcn" : 323,
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    "csi_rsrp" : null,
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    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -102,
    "physical_cell_id" : 117,
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    "spectrum_bandwidth" : null
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    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
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    "spectrum_band" : "",
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    "network_subtype" : "LTE",
    "signal_strength" : -102,
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    "spectrum_bandwidth" : null
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    "rsrq" : -16,
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    "arfcn" : 323,
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    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
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    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -95,
    "physical_cell_id" : 204,
    "network_generation" : "4G",
    "spectrum_bandwidth" : null
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    "rsrp" : -105,
    "rsrq" : -20,
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    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:05:16+00:00",
```

```
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  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
  "cqi" : null,
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  "rsrq" : -15,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
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  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -101,
  "physical_cell_id" : 117,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
  "cqi" : null,
  "rsrp" : -103,
  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "sinr" : null,
  "arfcn" : 323,
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  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:16+00:00",
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  "cell_connection" : 0,
  "network_subtype" : "LTE",
```

```
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  "rsrq" : -14,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:16+00:00",
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  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -98,
  "physical_cell_id" : 298,
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}, {
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  "rsrp" : -103,
  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:05:16+00:00",
  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -103,
  "physical_cell_id" : 240,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
} ],
"jitter" : 11683,
"targets" : [ "sp1-bdc-ashburn-us.samknows.com" ],
"duration" : 5104567,
"locations" : [ {
  "speed" : 0.16475181,
  "latitude" : 51.4952759,
  "longitude" : 0.0739276,
  "timestamp" : "2022-10-31T13:17:50+00:00",
  "speed_accuracy" : 0.22671568,
  "horizontal_accuracy" : 7
}, {
  "speed" : 0.3882077,
  "latitude" : 51.4952544,
  "longitude" : 0.0739211,
  "timestamp" : "2022-10-31T13:17:56+00:00",
  "speed_accuracy" : 0.4110961,
  "horizontal_accuracy" : 5
```

```
  } ],
  "timestamp" : "2022-10-31T13:17:56+00:00",
  "packets_sent" : 200,
  "success_flag" : true,
  "connection_type" : "cell",
  "round_trip_time" : 133616,
  "packets_received" : 200,
  "network_roaming_flag" : false,
  "network_available_flag" : true,
  "network_connected_flag" : true,
  "carrier_aggregation_flag" : false
},
"download" : {
  "cells" : [ {
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    "rsrp" : -102,
    "rsrq" : -20,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
    "timestamp" : "2022-10-28T13:04:42+00:00",
    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -102,
    "physical_cell_id" : 299,
    "network_generation" : "4G",
    "spectrum_bandwidth" : null
  }, {
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    "rsrp" : -100,
    "rsrq" : -16,
    "rssi" : null,
    "sinr" : null,
    "arfcn" : 323,
    "cell_id" : null,
    "csi_rsrp" : null,
    "csi_rsrq" : null,
    "csi_sinr" : null,
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    "spectrum_band" : "",
    "cell_connection" : 0,
    "network_subtype" : "LTE",
    "signal_strength" : -100,
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    "network_generation" : "4G",
    "spectrum_bandwidth" : null
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    "rsrq" : -18,
    "rssi" : null,
    "sinr" : null,
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    "cell_id" : null,
    "csi_rsrp" : null,
```

```
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  "csi_sinr" : null,
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  "network_generation" : "4G",
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  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:04:42+00:00",
  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -94,
  "physical_cell_id" : 204,
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  "spectrum_bandwidth" : null
}, {
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  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "sinr" : null,
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  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "rsrq" : -20,
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  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
  "signal_strength" : -104,
  "physical_cell_id" : 299,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
}, {
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  "rsrp" : -101,
  "rsrq" : -14,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
  "cell_id" : null,
  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
  "timestamp" : "2022-10-28T13:04:51+00:00",
  "spectrum_band" : "",
  "cell_connection" : 0,
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  "signal_strength" : -101,
  "physical_cell_id" : 117,
  "network_generation" : "4G",
  "spectrum_bandwidth" : null
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  "rsrq" : -20,
  "rssi" : null,
  "sinr" : null,
  "arfcn" : 323,
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  "csi_rsrp" : null,
  "csi_rsrq" : null,
  "csi_sinr" : null,
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  "spectrum_band" : "",
  "cell_connection" : 0,
  "network_subtype" : "LTE",
```

```
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      "arfcn" : 323,
      "cell_id" : 106766,
      "csi_rsrp" : null,
      "csi_rsrq" : null,
      "csi_sinr" : null,
      "timestamp" : "2022-10-28T13:04:51+00:00",
      "spectrum_band" : "",
      "cell_connection" : 0,
      "network_subtype" : "LTE",
      "signal_strength" : -94,
      "physical_cell_id" : 204,
      "network_generation" : "4G",
      "spectrum_bandwidth" : null
    } ],
    "targets" : [ "sp1-bdc-ashburn-us.samknows.com" ],
    "duration" : 4699159,
    "bytes_sec" : 611251,
    "locations" : [ {
      "speed" : 1.1327434,
      "latitude" : 51.4950762,
      "longitude" : 0.0741186,
      "timestamp" : "2022-10-31T13:17:24+00:00",
      "speed_accuracy" : 2.9904013,
      "horizontal_accuracy" : 53
    }, {
      "speed" : 1.2804528,
      "latitude" : 51.4952081,
      "longitude" : 0.0739935,
      "timestamp" : "2022-10-31T13:17:32+00:00",
      "speed_accuracy" : 0.31144822,
      "horizontal_accuracy" : 23
    } ],
    "timestamp" : "2022-10-31T13:17:31+00:00",
    "success_flag" : true,
    "connection_type" : "cell",
    "warmup_duration" : 3302554,
    "bytes_transferred" : 2872368,
    "network_roaming_flag" : false,
    "network_available_flag" : true,
    "network_connected_flag" : true,
    "carrier_aggregation_flag" : false,
    "warmup_bytes_transferred" : 1755438
  }
},
"test_id" : "576897402692",
"app_name" : "FCC Speed Test App",
"device_id" : "30932111-c5b0-456c-8855-9da9e5c5d913",
"device_tac" : null,
"app_version" : "3.1.4645",
"device_type" : "Android",
```

```
   "manufacturer" : "Samsung",
   "provider_name" : "Verizon",
   "in_vehicle_flag" : false,
   "device_timestamp" : "2022-10-31T13:17:56+00:00",
   "operating_system" : "Android 8.0.0",
   "server_timestamp" : "2022-10-31T13:17:58+00:00",
   "server_source_port" : 35578,
   "scheduled_test_flag" : false,
   "external_antenna_flag" : false,
   "net_mobile_country_code" : "310",
   "net_mobile_network_code" : "260",
   "sim_mobile_country_code" : "310",
   "sim_mobile_network_code" : "260",
   "server_source_ip_address" : "148.252.132.59"
  } ],
  "submission_category" : "Consumer Challenge"
}
```


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

After a user has navigated through the required user journey and upon initiating a test the following sequence of actions takes place:

- The app fetches the **stackpath-us** target set from the Speedtest API.
- The server selection process (described above) is performed against each of the targets in the list.
- 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.
- Pause of 2 seconds.
- The Upload test is performed against the chosen test server. The result and a snapshot of the current environmental data (see later) is captured.
- Pause of 2 seconds.
- 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.
- Pause of 2 seconds.
- The results are submitted to the backend Data Ingestion API and a resulting Test ID is retrieved.
- 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:

l. Download speed (Mbps)
m. Upload speed (Mbps)
n. Latency (ms)
o. Packet loss (%)
p. Jitter (ms)

q. Test ID (Provided there was successful submission of test results and thus a Test ID received back)
r. Connection Type (Indicates either the name of the wireless network that was tested if tests were purely conducted over cellular or indicates a Wi-Fi connection with the SSID if tests were conducted over Wi-Fi at any point in the test sequence)

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.

If the same above test results are viewed inside the Test History section, the following additional Test Details are also displayed;

s. Coordinates (The latitude and longitude of the location where the test took place)
t. Test Server (The location of the test server)
u. Tested By (The name of the individual who conducted the test, if a name was supplied by the user)
v. Date (The date and time of measurement)

Table 2: iOS Data Dictionary

The set of tables below define a collective list of all the data fields that are both collected during the tests and the fields that are generated server-side. A small subset of fields which purely only feature as part of the submission from the iOS app to the backend ingest are also listed for completeness.

The table below lists all possible fields that are reported by the iOS app to the SamKnows backend ingest.

Field Name	Description
submission_category	The category of the data submission. This represents an enumerated value and must be one of the following; **Consumer Crowdsourced** | **Consumer Challenge** | **Entity Crowsourced** | **Entity Challenge** | **Provider Response** | **Other**
name	The full name of the user
email	The email address of the user. Value must match valid email address format eg. **user@domain.tld**
phone	The phone number of the user. Value must match valid US phone number format eg. **000-0000-0000** . This value may be *null* of the *submission_category* is one of the following; *Consumer Crowdsourced* | *Entity Crowsourced* | *Provider Response* | *Other*
device_timestamp	The timestamp of the moment at which the test submission to the backend is first attempted. This is measured by the device and adheres to the ISO-8601 format

Field Name	Description
	which includes seconds and time zone offset eg. **YYYY-MM-DD[T]hh:mm:ss±hh:mm**
device_type	Indicates the type of device used. This represents an enumerated value and must be one of the following; **iOS | Android | Other**
manufacturer	The name of the manufacturer of the device eg. **Google**
model	The name of the device model eg. **PIXEL 6**
operating_system	Name and version of the device's operating system eg. **Android 12**
device_id	A unique device identifier generated by the app on the device, on an individual app-installtion basis eg. **a255e318-df8d-46d1-a23b-9589e4d2e53e** . If anonymisation is true however, this device identifier is re-generated randomly for each submission to further promote privacy.
app_name	The name of the mobile speed test app. In the case of the BDC app, this is always **FCC Speed Test App**
app_version	The version of the mobile speed test app eg. **v4.3.0 b14**
provider_name	The name of the mobile service provider eg. **T-Mobile**
sim_mobile_country_code	The mobile country code of mobile service provider reported for the active SIM card in the device eg. **310**
sim_mobile_network_code	The mobile network code of mobile service provider reported for the active SIM card in the device eg. **260**
in_vehicle_flag	Indicates whether the test was conducted while in-vehicle or outdoors.
external_antenna_flag	Indicates whether an in-vehicle test was conducted with an antenna external to the vehicle. Note that when *in_vehicle_flag* is false, this value must also be *false*
scheduled_test_flag	Indicates whether the test was automated/scheduled or whether it was user-initiated manually.
timestamp	The timestamp of the moment at which the connection for a test metric was initialized or when a respective value or set of values were captured. This is measured by the device and adheres to the ISO-8601 format which includes seconds and time zone offset eg. **YYYY-MM-DD[T]hh:mm:ss±hh:mm**
warmup_duration	The duration that the connection took to stabilize before the test metric commenced. Applies to only the Download and Upload tests.
warmup_bytes_transferred	The total amount of data that was transferred during the period the connection took to stabilize before the test metric commenced. Applies to only the Download and Upload tests.
duration	The duration that the test metric took to complete.

Field Name	Description
bytes_transferred	The total amount of data that the test metric transferred. Applies to only the Download and Upload tests.
bytes_sec	The number of bytes per second that the test metric transferred. Also known as *Throughput*. Applies to only the Download and Upload tests.
targets	An array of hostnames/IP addresses of the targets servers used for conducting the test metric against. Eg. **["sp2-vm-ashburn-us.samknows.com"]** .
success_flag	Indicates whether the test completed successfully, without a change in state or connectivity.
round_trip_time	The round-trip latency. This value only applies to the Latency test.
jitter	Calculated variation in latency between packets flowing between device and server. This value only applies to the Latency test.
packets_sent	The number of packets sent during the test. This value only applies to the Latency test. The full amount of packets sent by the BDC app is **200**
packets_received	The number of packets received during the test. This value only applies to the Latency test.
latitude	The unprojected (WGS-84) geographic coordinate latitude of the reported location where the test was conducted.
longitude	The unprojected (WGS-84) geographic coordinate longitude of the reported location where the test was conducted.
horizontal_accuracy	The horizontal accuracy of the location coordinates radially, measured from the device. The value may also be null if the device does not return a valid value.
speed	The speed of the device at the time test was conducted. The value may be null if a valid value cannot be obtained at the time of measurement. The value may also be null if the submission_category is either Consumer Crowsourced, Entity Crowdsourced or Other
speed_accuracy	The speed accuracy of the device at the time the test was conducted. The value may be null if a valid value cannot be obtained at the time of measurement. The value may also be null if the device does not return a valid value.
network_generation	The network generation of the cell. The value is always one of the following; **2G** | **3G** | **4G** | **5G** | **Other**
network_subtype	The network subtype of the cell. The value is always one of the following; **1X | EVDO | WCDMA | GSM | HSPA | HSPA+ | LTE | NRSA | NRNSA**

The following fields are generated server-side and are also present in the data transferred from the SamKnows backend to the BDC backend. They are also present in the local device export data.

Field Name	Description
test_id	The unique identifier used by the app or entity to differentiate tests.

Field Name	Description
server_timestamp	The timestamp measured by the server of the moment at which the test submission data was received by the app's servers
server_source_port	The source TCP port of the device submitting test submission data, measured by the server
server_source_ip_address	The source IP address of the device submitting test submission data, measured by the server

The following additional fields are only submitted by the iOS app to the SamKnows ingest and are not relevant and therefore not present in the data transferred to the BDC backend or the local device export.

Field Name	Description
agentId	A unique identifier originally generated by the SamKnows backend and returned to the app when the initial registration call is made. Eg **b264f318-df8d-46d1-a23b-9589e4d2e53e** This identifier is generated on an initial registration basis for each app and linked to a panel.
anonymised	Indicates to the ingest whether the device_id is persistent. If anonymised is true, each device_id is never linked to more than one set of results, to ensure greater privacy. For the BDC apps this always has a value of **false**
version	The version of the JSON schema. For the BDC apps this always has a value of **2**
connection_type	Indicates the type of connection over which the test was conducted. Always has one of two possible values; **cell** or **wi-fi**

The comprehensive list of field names described in the tables above, along with additional information is also provided separately, in the accompanying Data Dictionary files.

FCC BDC App 2022 - Data Dictionary (Apps to SK Backend).xlsx
FCC BDC App 2022 - Data Dictionary (SK Backend to BDC Backend).xlsx
FCC BDC App 2022 - Data Dictionary (Device Export).xlsx

JSON Reporting Format Example for iOS

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


```
{
  "anonymised": false,
  "agentId": "89c96256-44c1-4384-8ace-246a4cfa2b0e",
  "source_name": "FCC BDC App",
  "version": 2,
  "body": {
```

```
"submission_category": "Consumer Challenge",
"contact": {
  "name": "John Doe",
  "email": "john.doe@gmail.com",
  "phone": "002346762534"
},
"submissions": [
  {
    "test_id": "123456789",
    "device_timestamp": "2022-01-20T00:00:00+00:00",
    "server_timestamp": "2022-01-20T00:00:35+00:00",
    "server_source_ip_address": "172.58.189.166",
    "server_source_port": 3743,
    "device_type": "iOS",
    "manufacturer": "Apple",
    "model": "iPhone14,5",
    "operating_system": "iOS 15.2",
    "device_id": "28a24540-56f8-4384-8ace-246a4cfa2b0e",
    "app_name": "FCC Speed Test app",
    "app_version": "v4.2.2 b1",
    "provider_name": "T-Mobile",
    "sim_mobile_country_code": "310",
    "sim_mobile_network_code": "260",
    "in_vehicle_flag": false,
    "external_antenna_flag": false,
    "scheduled_test_flag": false,
    "tests": {
      "download": {
        "timestamp": "2022-01-20T00:00:02+00:00",
        "warmup_duration": 3001787,
        "warmup_bytes_transferred": 36031636,
        "duration": 5000802,
        "bytes_transferred": 67948392,
        "bytes_sec": 19487461,
        "locations": [
          {
            "timestamp": "2022-01-20T00:00:02+00:00",
            "latitude": 36.1835702,
            "longitude": -78.3661906,
            "horizontal_accuracy": 65,
            "speed": 6.5,
            "speed_accuracy": 1.0
          },
          {
            "timestamp": "2022-01-20T00:00:10+00:00",
            "latitude": 36.1835702,
            "longitude": -78.3661906,
            "horizontal_accuracy": 65,
            "speed": 6.5,
            "speed_accuracy": 1.0
          }
        ],
        "cells": [
                        {
            "timestamp": "2022-01-20T00:00:02+00:00",
            "network_generation": "4G",
            "network_subtype": "LTE"
          },
          {
            "timestamp": "2022-01-20T00:00:10+00:00",
```

```
      "network_generation": "4G",
      "network_subtype": "LTE"
    }
  ],
  "targets": ["sp1-vm-ashburn-us.samknows.com"],
  "success_flag": true,
                    "connection_type": "cell"
},
          "upload": {
  "timestamp": "2022-01-20T00:00:12+00:00",
  "warmup_duration": 3001787,
  "warmup_bytes_transferred": 36031636,
  "duration": 5000105,
  "bytes_transferred": 7775576,
  "bytes_sec": 1555082,
  "locations": [
    {
      "timestamp": "2022-01-20T00:00:12+00:00",
      "latitude": 36.1835702,
      "longitude": -78.3661906,
      "horizontal_accuracy": 65,
      "speed": 6.5,
      "speed_accuracy": 1.0
    },
    {
      "timestamp": "2022-01-20T00:00:20+00:00",
      "latitude": 36.1835702,
      "longitude": -78.3661906,
      "horizontal_accuracy": 65,
      "speed": 6.5,
      "speed_accuracy": 1.0
    }
  ],
  "cells": [
                      {
      "timestamp": "2022-01-20T00:00:12+00:00",
      "network_generation": "4G",
      "network_subtype": "LTE"
    },
    {
      "timestamp": "2022-01-20T00:00:20+00:00",
      "network_generation": "4G",
      "network_subtype": "LTE"
    }
  ],
  "targets": ["sp1-vm-ashburn-us.samknows.com"],
  "success_flag": true,
                    "connection_type": "cell"
},
"latency": {
  "timestamp": "2022-01-20T00:00:22+00:00",
  "duration": 5129955,
  "round_trip_time": 40915,
  "jitter": 7611,
  "packets_sent": 200,
  "packets_received": 200,
  "locations": [
    {
      "timestamp": "2022-01-20T00:00:22+00:00",
      "latitude": 36.1835702,
```

```
            "longitude": -78.3661906,
            "horizontal_accuracy": 65,
            "speed": 6.5,
            "speed_accuracy": 1.0
          },
          {
            "timestamp": "2022-01-20T00:00:30+00:00",
            "latitude": 36.1835702,
            "longitude": -78.3661906,
            "horizontal_accuracy": 65,
            "speed": 6.5,
            "speed_accuracy": 1.0
          }
        ],
        "cells": [
          {
            "timestamp": "2022-01-20T00:00:22+00:00",
            "network_generation": "4G",
            "network_subtype": "LTE"
          },
          {
            "timestamp": "2022-01-20T00:00:30+00:00",
            "network_generation": "4G",
            "network_subtype": "LTE"
          }
        ],
        "targets": ["sp1-vm-ashburn-us.samknows.com"],
        "success_flag": true,
                        "connection_type": "cell"
      }
    }
  }
 ]
}
}
```


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:


```
{
 "contact" : {
   "name" : "John Doe",
   "email" : "john.doe@gmail.com",
   "phone" : "123-456-7890"
 },
 "submissions" : [ {
   "model" : "iPhone13,3",
   "tests" : {
     "upload" : {
       "cells" : [ {
         "timestamp" : "2022-06-17T09:23:16+01:00",
         "network_subtype" : "NRNSA",
         "network_generation" : "5G"
       }, {
         "timestamp" : "2022-06-17T09:23:25+01:00",
```

```
    "network_subtype" : "NRNSA",
    "network_generation" : "5G"
   } ],
   "targets" : [ "sp1-bdc-ashburn-us.samknows.com"],
   "duration" : 7,
   "bytes_sec" : 4833127,
   "locations" : [ {
    "speed" : 0,
    "latitude" : 51.499056103687266,
    "longitude" : -0.08057867176838272,
    "timestamp" : "2022-06-17T09:23:16+01:00",
    "speed_accuracy" : 0.8199999928474426,
    "horizontal_accuracy" : 5.2103220610157965
   }, {
    "speed" : 0,
    "latitude" : 51.49900748864919,
    "longitude" : -0.08051421493299353,
    "timestamp" : "2022-06-17T09:23:24+01:00",
    "speed_accuracy" : 0.97268957554361,
    "horizontal_accuracy" : 4.56473696778758
   } ],
   "timestamp" : "2022-06-17T09:23:25+01:00",
   "success_flag" : true,
   "connection_type" : "cell",
   "warmup_duration" : 3000549,
   "bytes_transferred" : 24148984,
   "warmup_bytes_transferred" : 18061796
  },
  "latency" : {
   "cells" : [ {
    "timestamp" : "2022-06-17T09:23:25+01:00",
    "network_subtype" : "NRNSA",
    "network_generation" : "5G"
   }, {
    "timestamp" : "2022-06-17T09:23:30+01:00",
    "network_subtype" : "NRNSA",
    "network_generation" : "5G"
   } ],
   "jitter" : 717,
   "targets" : [ "sp1-bdc-ashburn-us.samknows.com" ],
   "duration" : 5000518,
   "locations" : [ {
    "speed" : 0,
    "latitude" : 51.49900748864919,
    "longitude" : -0.08051421493299353,
    "timestamp" : "2022-06-17T09:23:24+01:00",
    "speed_accuracy" : 0.97268957554361,
    "horizontal_accuracy" : 4.56473696778758
   }, {
    "speed" : 0.6999999880790668,
    "latitude" : 51.49900375248968,
    "longitude" : -0.08047086245377393,
    "timestamp" : "2022-06-17T09:23:29+01:00",
    "speed_accuracy" : 1.0244705031505903,
    "horizontal_accuracy" : 4.9486524627164625
   } ],
   "timestamp" : "2022-06-17T09:23:30+01:00",
   "packets_sent" : 200,
   "success_flag" : true,
   "connection_type" : "cell",
```

```
      "round_trip_time" : 30932,
      "packets_received" : 200
    },
    "download" : {
      "cells" : [ {
        "timestamp" : "2022-06-17T09:23:08+01:00",
        "network_subtype" : "NRNSA",
        "network_generation" : "5G"
      }, {
        "timestamp" : "2022-06-17T09:23:16+01:00",
        "network_subtype" : "NRNSA",
        "network_generation" : "5G"
      } ],
      "targets" : [ "sp1-bdc-ashburn-us.samknows.com" ],
      "duration" : 5000588,
      "bytes_sec" : 29748792,
      "locations" : [ {
        "speed" : 0.7400000095367381,
        "latitude" : 51.49894772007256,
        "longitude" : -0.08045653990124271,
        "timestamp" : "2022-06-17T09:22:52+01:00",
        "speed_accuracy" : 1.8610250916810664,
        "horizontal_accuracy" : 9.634415761442106
      }, {
        "speed" : 0,
        "latitude" : 51.499056103687266,
        "longitude" : -0.08057867176838272,
        "timestamp" : "2022-06-17T09:23:16+01:00",
        "speed_accuracy" : 0.8199999928474426,
        "horizontal_accuracy" : 5.2103220610157965
      } ],
      "timestamp" : "2022-06-17T09:23:16+01:00",
      "success_flag" : true,
      "connection_type" : "cell",
      "warmup_duration" : 3003951,
      "bytes_transferred" : 148761456,
      "warmup_bytes_transferred" : 124234214
    }
  },
  "test_id" : "3098378219",
  "app_name" : "FCC Speed Test App",
  "device_id" : "441025F0-4C2B-4060-ABD8-B4DD3CF777B2",
  "app_version" : "v4.3.0 b10",
  "device_type" : "iOS",
  "manufacturer" : "Apple",
  "provider_name" : "Verizon",
  "in_vehicle_flag" : false,
  "device_timestamp" : "2022-06-17T09:23:30+01:00",
  "operating_system" : "iOS 15.4",
  "server_timestamp" : "2022-06-17T08:20:00+00:00",
  "server_source_port" : 7368,
  "scheduled_test_flag" : false,
  "external_antenna_flag" : false,
  "sim_mobile_country_code" : "310",
  "sim_mobile_network_code" : "260",
  "server_source_ip_address" : "85.255.237.194"
 } ],
 "submission_category" : "Consumer Challenge"
}
```

III. FCC Speed Test App Privacy Notice and Terms of Use (updated October 21, 2022)

Note: This Privacy Policy applies to both the current version of the FCC Speed Test App and the upcoming release of the app that will allow users to run mobile challenge and crowdsource speed tests for the FCC's Broadband Data Collection. This Privacy Policy does not apply to how your mobile device collects, uses, retains, and discloses information, including from the App, which are subject to your device provider's privacy policies.

What Information We Collect

The FCC Speed Test app (App) collects limited information that can be used (1) to measure your mobile (including WiFi-enabled) broadband connection performance; (2) to permit the coordination and adjudication of challenges that are submitted as part of the Federal Communications Commission's Broadband Data Collection (BDC); and (3) to properly validate crowdsourced data that are submitted as part of the BDC. We collect personally identifiable information for these purposes only with your permission. Examples of personally identifiable information the App collects include your name, phone number, email address, location (including street address and/or geographic coordinates of the speed test), network information, timestamp, or identifiers associated with the speed test or your device.

More specifically, in addition to your contact information, we collect the following five broad categories of information when you use this App (for a complete listing of data fields, see Broadband Data Collection Data Specifications for Mobile Speed Test Data).

1. Location (only with your express permission)

- The App requires location permission to perform a speed test, and once it is enabled, the App will report your network name and your physical location when using the App (which includes the geographic coordinates of the location(s) measured during a speed test, and, if available, the horizontal accuracy and speed a vehicle is traveling if the test is taken in motion).
    - When using the App, you will be prompted to select whether and how often the App may access location information. If you do not provide permission, the App will not perform a speed test.
    - When you run a speed test, the App may collect information related to the cellular network environment in addition to your physical location when using the App.

- When possible, we will aggregate your location data with other users' location data to provide aggregated network performance and coverage statistics.

2. Time of Data Collection

- The App will report the date and time (and the time zone) when it performs measurements of your mobile 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. Date and time of the test are also important factors for the FCC to consider when determining whether inaccuracies in providers' reported coverage are persistent. Time zone is an important metric to capture as it allows the comparison of measurements against known outages.

3. Device and Network Information

- The App reports your device type, manufacturer (brand), model, the operating system type and version installed on your device, and the timestamp that test measurement data were transmitted to the App developer's servers, as well as the source Internet Protocol (IP) address and port of the device's connection, as measured by the server. The App also collects certain Transmission Control Protocol (TCP) and IP information that will be used to coordinate and adjudicate BDC challenges.

4. Mobile Wireless Network Performance and Characteristics

- The App will report, to the extent available based on the operating system used, information about your mobile device connection performance, such as your service provider, the strength and quality of the radio frequency signal, and the connection technology type and spectrum band used for the test.

5. Broadband Performance

- If you are not connected to WiFi, the App tests and reports your mobile broadband upload and download speeds, 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.

- If you conduct a test while connected to WiFi and cellular services are turned on, the App will report the performance of your connection through the WiFi network, but it will also record some information related to the cellular network environment.

How We Use and Share the Data

We share the data collected by the App in five ways to help consumers, the FCC, and others interested in understanding mobile broadband availability and performance in the United States. Note that the App does not use your data to support the delivery of first-party or third-party advertisements.

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. To Mobile Internet Service Providers Whose Coverage Is Being Challenged via the FCC Broadband Data Collection

- We will share certain identifying information with mobile broadband service providers in order to help resolve challenges and conflicting coverage information reflected in broadband service providers' availability filings and the verified availability data submitted to the FCC by other Federal agencies, state, local, and Tribal governmental entities that are primarily responsible for mapping or tracking broadband service coverage, and other relevant third parties. Before a service provider receives access to any crowdsource or challenge data, it will be required, within the BDC platform, to acknowledge that it will use personally identifiable information that it receives for the sole purpose of responding to a challenge and that it will protect and keep private all such personally identifiable information.

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

- Your data will be shared 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 developed the FCC Speed Test App, 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 (NDAs) to analyze the collected data for privacy risks or concerns and to plan for future measurement efforts.

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

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

5. To You and the Public

- As a user, you can download your own speed test results data from the App and use or share those data as you see fit. Certain challenge and crowdsource information, including the precise locations of challenges in the BDC, will be depicted on the FCC's website and used to verify and correct the FCC's broadband availability maps. We will also publish de-identified data in summary statistics, coarsened data, and other minimally necessary datasets that support our review of the statistics, but only if we determine that the data poses very low risks to your privacy.

    - **BDC Challenge and Crowdsourced Data**
      Locations that are challenged through the mobile challenge process in the BDC will be made public via the Commission's website, including the street address and/or geographic coordinates of the test, as relevant, as well as in aggregate form. Location information related to the crowdsourcing process will also be made public via the Commission's website. Non-location information associated with the BDC's challenge or crowdsourcing processes, such as names, phone numbers, email addresses, or mobile device information, will not be posted on the website or otherwise made publicly available.

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

- **Coarsened Data**
  We will publish 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.

- **Improved Broadband Mapping**
  The FCC will use de-identified data to reflect the general location, time, and results of the tests, which will help inform the public on the availability of mobile broadband and aid the FCC in its efforts to improve broadband mapping and access to broadband. Your test results may be aggregated with the results of other tests conducted nearby to minimize the risk of identification. The Commission's aggregated mapping data or other visual depictions may be shared publicly via online maps, in reports, or in other formats.

How We Protect Data

The FCC protects its information resources with a dynamic set of security measures. Some of these measures (e.g., network firewalls, physical security) protect the entire FCC enterprise, while other measures (e.g., user access restrictions, encryption) are applied to specific information systems. Following the risk-based policy established in the Federal Information Modernization Act (FISMA), the FCC applies more security measures (also known as security "controls") to information systems that present higher operational risks. Consistent with this policy, the FCC applies specific security controls to systems that collect and process Privacy Act records and other identifying information. A comprehensive list of the security and privacy controls the FCC may apply to its information systems can be found in National Institute of Standards and Technology (NIST) Special Publication (SP) No. 800-53, Revision 5. Finally, the BDC resides within the FCC instance of AWS, which is FedRAMP accredited, and any customer responsibility controls are addressed through NIST SP No. 800-53.

The electronic records, files, and data are stored within FCC or a vendor's accreditation boundaries and maintained in a database housed in the FCC's or vendor's computer network databases. Access to the electronic files is restricted to authorized employees and contractors; and to IT staff, contractors, and vendors who maintain the IT networks and services. Other employees and contractors may be granted access solely on a need-to-know basis. The electronic files and records are protected by the FCC and third-party privacy safeguards, a

comprehensive and dynamic set of IT safety and security protocols and features that are designed to meet all Federal privacy standards, including those required by the Federal Information Security Modernization Act of 2014 (FISMA), the Office of Management and Budget (OMB), and the National Institute of Standards and Technology (NIST).

Our contractor, SamKnows, maintains appropriate administrative, technical, and physical safeguards to ensure the security and confidentiality of the personally identifiable information collected by the App against any hazards to their security or integrity. SamKnows conforms to the FCC's privacy and security policies and terms and conditions. SamKnows maintains all test data containing personally identifiable information within the United States.

Other Terms and Conditions of Your Participation

1. Data Consumption

By default, the App is configured to use no more than 1 gigabyte (GB) of data each month for speed testing. At any time, you can change the amount of data the App uses by increasing or reducing the "monthly data usage" in the Settings menu; however, if a test sequence is initiated prior to the data cap, the App may exceed the limit in order to complete the sequence. 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.

2. 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, including your contact information, may remain on your device so that it can be repopulated into the App if you reinstall it. Any prior collected data will also remain in the data sets subject to the above terms and protections.

3. 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).
- 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]