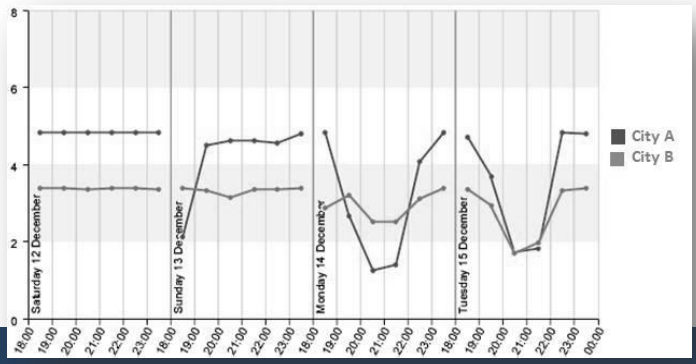
epitiro
The Broadband Communications Authority

KPI Packs

Broadband, Voice, Video & Mobile



- Broadband Test Application (BTA)
- Mobile Test Application
- Traffic Management & TCP Throughput Test Application
- Advanced Voice Analysis Application
- Advanced Video Analysis Application

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About KPI Packs

Epitiro probes can be configured to run various KPI Packs to analyse specific network areas. The following packas are describe din detail in this document;

- Broadband Test Application (BTA)
- Mobile Test Application
- Traffic Management & TCP Throughput Test Application
- Advanced Voice Analysis Application
- Advanced Video Analysis Application

Broadband Test Application
The Broadband Test Application KPI Pack contains the metrics used for analysis of the world's most popular internet functions; web surfing , email, playing games and general file sending. Metrics include HTTP speed, DNS lookup time, Ping, Packet Loss, Jitter and E-Model VoIP voice quality, email delivery time/success and FTP speed. Failures are also recorded. The Broadband Test Application works on all probe types.

Traffic Management & TCP Throughput Test Application
The Traffic Management & TCP Throughput Test Application is used to analyze am ISP's performance in terms of assessing maximum 'up to' speeds according to the rate in which very large files are downloaded. Traffic designed to appear as P2P files can be streamed to capture views of Traffic Management practices.

Advanced Voice Analysis Application (PESQ)
The Advanced Voice Analysis Application uses ITU standard P.862 PESQ to measure actual speech quality known as MOS. The quality measurement algorithm is used for all network types. PESQ compares an original reference voice sample with the degraded output from the far-end. The overall audio quality is measured as well as other audio characteristics such as background noise, volume differential and one-way audio delay.

Advanced Video Analysis Application
Video Streaming can be analysed from a consumer application viewpoint with the Advanced Video Analysis. Live-playback and measurement of streaming media and can be configured to stream video and audio from either a live or on-demand URL, for a specified period of time. Supported streaming protocol support includes RTSP, MMS, and HTTP.

Mobile Test Application
Used in conjunction with the Broadband Test Application, the Mobile Test Application includes SMS testing and a collection of network layer metrics such as RSSI, SNR, GPS, Speed & Direction (for in-motion testing), BER and more.

Each KPI Pack records complementary data for each test such as time of test, location, service provider and failure rates. The test frequency and selection of endpoints (URLs, servers) for far-end testing are selectable by the client.

1 Broadband Test Application KPI Pack

Epitiro's Broadband Test Application tests a comprehensive suite of consumer experience metrics designed to measure quality of service of the most popular web activities – surfing, email and game playing. The BTA operates on all probe types.

Each probe operates the Broadband Test Application

Broadband Test Application (BTA) Metrics	Units
Performance	
Synchronization Speed	Mbps
HTTP Download Speed	Mbps
TCP Download / Upload Speed	Mbps
FTP Download / Upload Speed	Mbps
Traceroute	IP Address Hops
DNS Time Resolution Time	msec
Ping Time	msec
Packet Loss	# of lost Packets
Failures on above metrics	Number of Tests/Failures/Successes
Location & Time	
Date	Day/ Month/Year
Time of Day	00:00-24:00
Location	Address of Panellist Country, Town, Street Address, Post Code
IP Address	XXX.XXX.XXXX
Probe ID	Epitiro Unique Identifier
ISP Information	
ISP	Name of ISP
ISP Package	Name/Speed
Test Device	
CPE or Consultant Hardware information	Modem device type, model

2 Mobile Test Application KPI Pack

The Mobile Test Application Pack contains all of the metrics required to fully comprehend mobile SMS, Broadband and VoIP services.

Mobile Test Application (BTA) Metrics		Units
Performance		
Synchronization Speed		Mbps
HTTP Download Speed		Mbps
TCP Download / Upload Speed		Mbps
FTP Download / Upload Speed		Mbps
Traceroute		IP Address Hops
DNS Time Resolution Time		msec
Ping Time		msec
Packet Loss		# of lost Packets
Failures on above metrics		Number of Tests/Failures/Successes
Date		Day/ Month/Year
Time of Day		00:00-24:00
IP Address		XXX.XXX.XXXX
Probe ID		Epitiro Unique Identifier
ISP Information		
ISP		Name of ISP
ISP Package		Name/Speed
Test Device		
CPE or Consultant Hardware information		Modem device type, model
Network Availability (by Access Protocol)	%age of network availability for each Operators network by region and by access technology (NO_NETWORK, GPRS, EDGE, 3G, HSDPA, HSUPA ...)	

Location	
Latitude	Returns the latitude of the fix.
Longitude	Returns the longitude of the fix.
UTC timestamp	UTC time of this fix, in milliseconds since January 1, 1970.
Distance to Basestation *	Returns the distance in meters between this probe and serving the NodeB
PSC	Primary Scrambling Code – 9 bits format in UMTS only
Altitude	Returns the altitude of this fix.
Speed	Returns the speed of the device over ground in meters/second *(for in-motion testing)*
Bearing	Returns the direction of travel in degrees East of true North *(for in-motion testing)*

Radio Frequency (RF) Information - per individual test	
Location Area Code (LAC)	Location Area Code for the fix
Cell ID	ID of serving NodeB for the fix
LAC	Location Area Code
Received Signal Strength	The current received signal strength (dBm) for the fix - as defined in TS 27.007 8.5
SNR – Signal Quality	The current Signal to Noise Ratio - a measure of signal quality for the fix
RSCP	The level index of CPICH RSCP of the fix defined in TS 25.125
Access Protocol	GPRS, EDGE, UMTS, HSDPA, HSUPA, HSPA, ETC..
BERT / BLER	Bit/Block Error Rates (TS 27.007 8.5)
EC/IO	total power spectral density for the fix
Neighbouring Cell Info	Neighbouring Cell Info (CellD, LAC, dBm) is also available (if required)
CQI	CQI Information

3 Advanced Voice Analysis KPI Pack

The Advanced Voice Analysis Application uses ITU standard P.862 PESQ to measure actual speech quality known as MOS. The quality measurement algorithm is used for all network types. PESQ compares an original reference voice sample with the degraded output from the far-end. The overall audio quality is measured as well as other audio characteristics such as background noise, volume differential and one-way audio delay.

While MOS voice quality scores are an indicator of customer experience, other metrics are also recorded such as call setup times, dropped calls as well as network information unique to the voice access technologies being used.

The AT400 probe is capable of both initiating and receiving voice calls to and from other AT400 probess within the network. VoIP (Voice over IP) calls using SIP (Session Initiation Protocol) are supported as well as analogue calls over PSTN.

In the describing and reporting the metrics that relate to Voice testing in ISP-I, the terms upstream and downstream are defined as follows:

- Upstream – transmission of audio/data from the caller (initiator of the call) to the listener (recipient of the call)

- Downstream – transmission of audio/data to the caller, from the listener.

Prior to making a voice call, the calling probe remotely negotiates with the recieving probe that is to be the recipient of the call to ensure that it is ready to receive a call (i.e. it is connected – to the internet in the case of VoIP – and is not busy executing any other tests). If negotiation with the other probe is unsuccessful, then the calling probe will wait for a configured amount of time before retrying. Otherwise, after successful negotiation, the probe proceeds to initiate the call.

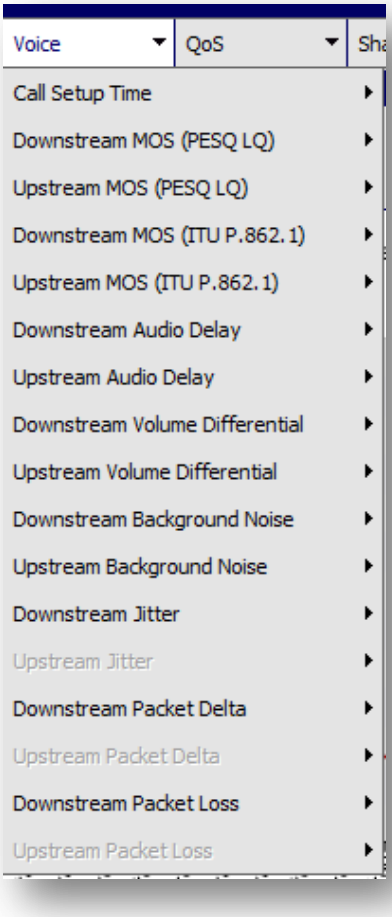
When making or receiving VoIP calls probes can be configured to use a specific audio codec and also supports DSCP marking in the Differentiated Services field of the IP packet headers that is often used to ensure that the VoIP traffic gets correctly routed and prioritised through the service provider's network.

Once a call has been successfully setup between the calling and receiving probes, the calling probe plays a reference speech signal upstream on the connected voice circuit to the receiving probethat records the incoming degraded audio. During playback of the reference, the caller also records the audio return for the purposes of echo analysis (see below). The same reference speech signal is then played downstream by the receiver and recorded by the caller. The receiver also records the audio return during playback. Once both caller and receiver have recorded a degraded audio signal and audio return, the call is terminated.

Upon termination of a successful call, the calling probe performs an analysis of the degraded audio signals (upstream and downstream). ITU standard PESQ is used to compare the degraded audio with the reference signal. PESQ (Perceptual Evaluation of Speech Quality) is an ITU-T standard (P.862) that provides an objective measure of speech quality over the

connected voice circuit. An analysis is also carried out to look for unacceptable levels of echo that may be present in the recorded audio returns. Echo is determined to be unacceptable by comparing it to the echo tolerance curve defined by the ITU standard G.131.
The analysis of the degraded audio and audio returns, results in the following metrics being recorded for both upstream and downstream transmission:

- PESQ LQ MOS (Mean Opinion Score) on a scale from 1 to 5
- ITU P.862.1 MOS on a scale from -0.5 to 4.5
- Delay – delay introduced to the audio during transmission
- Volume Differential – the difference in volume between reference and degraded signals
- Background Noise Differential – the gain in noise present in the signal after transmission



During the call, measurement of the network transmission of the audio data, results in the following metrics being recorded:

- Packet Delta – The arithmetic mean of the RTP audio packet inter-arrival time.
- Jitter – Estimate of the statistical variance of the RTP audio packet inter-arrival time.
- Packet Loss – The number of RTP packets that are not received, as detected by non-contiguous sequence numbers.

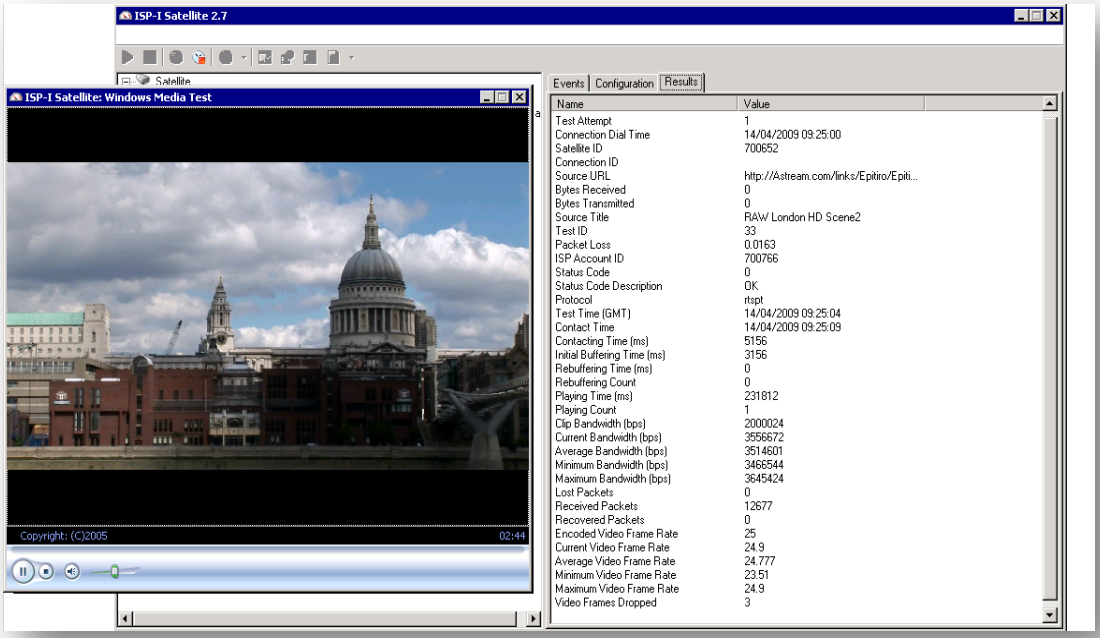
The three network transmission metrics described above are only available for test scenarios where VoIP endpoints are involved as follows:

- VoIP to VoIP – Network metrics available downstream and upstream
- VoIP to PSTN – Network metrics available downstream
- PSTN to VoIP – Network metrics available upstream

Voice Test Application Metrics	Units
All	
Call Setup Time	msec
Call Duration	Sec
MOS (Voice Quality)	R Factor / P.800 1-5 MOS
Audio Delay	msec
Volume Differential	db
Background Noise	db
UDP Fixed Rate	Mbps
Location & Time	
Date	Day/ Month/Year
Time of Day	00:00-24:00
Location	Address of Panellist Country, Town, Street Address, Post Code
IP Address	XXX.XXX.XXXX
Probe ID	Epitiro Unique Identifier

4 Advanced Video Analysis KPI Pack

The Advanced Video Analysis KPI Pack measures live-playback and measurement of streaming media in both Windows Media and Real formats. Probes can be configured to stream video and audio from either a live or on-demand URL, for a specified period of time. Supported streaming protocol support includes RTSP, MMS, and HTTP.



The following key metrics are recorded during the course of the stream.

- Contact Time – the time to contact the streaming media server
- Buffer Time – initial buffering time required before playback
- Start-up time – the time taken to contact the hosting server plus the time taken buffering prior to the start of playback.
- Rebuffering – the amount of time spent rebuffering (relative to the amount of time in playback).
- Bandwidth – the average bandwidth achieved (relative to the bandwidth of the encoded stream).
- Application level Packet Loss and Recovery[7] – the number of lost/late/out of order/recovered packets (relative to the number of normally received packets).
- Maximum Bandwidth – Max rate achieved during sequence
- Minimum Bandwidth – Min rate achieved during sequence
- Frame rates – Average Minimum and maximum video frame rates achieved (relative to the frame rate of the encoded stream) during play-back
- Dropped frames – number or percentage of frames dropped during sequence
- Codecs – Video and Audio codec information and bit rates.
- CODEC encoding support can begin at 8Kbps and be incremented right up to HD rate (2Mb+)

Any errors that occur during setup or playback of the stream are also recorded by ISP-I™.

Video Test Application Metrics	Units
Start-up time	msec
Non-playing time (msecs)	msec
Re-buffering Time (msecs)	msec
Bandwidth/Throughput (kbps)	kbps
Delivered Bandwidth	Mbps
Delivered Frame Rate	fps
Frame Drops	Number & %
Packet Loss	%

5 Detailed Description of Tests and Metrics

The following section described the tests that KPI Packs conduct and the main metrics that result from running those tests.

5.1 Connectivity

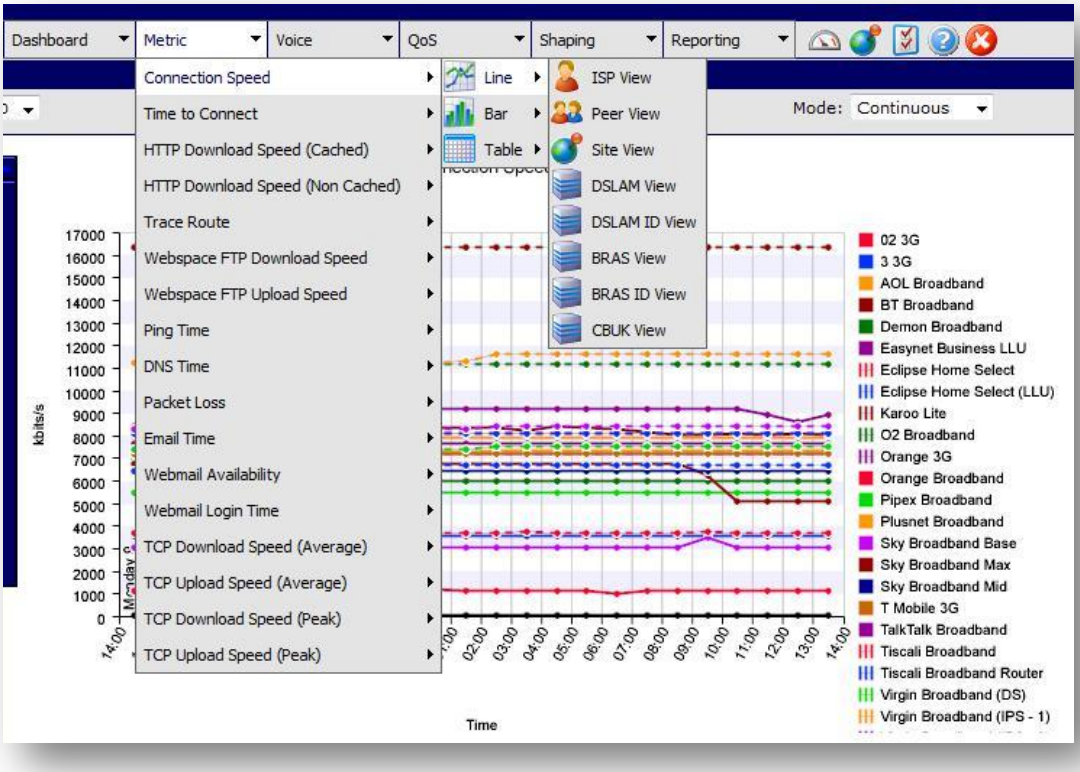
When connecting to a service via a modem (this includes dialup, ADSL over USB and 3G / HSDPA / GPRS wireless connections), the software employs the Windows RAS APIs to initiate the connection. This is the same underlying mechanism that an end user would be using when they manually initiate a connection to their ISP. This low-level of integration with Windows enables the KPI Pack to capture accurate timings for events that occur during the initialisation and setup of the connection (e.g. user authentication and IP address allocation), as well as the connection speed itself as reported by the device.

Additionally, where a connection failure occurs, KPI Pack records the specific error code returned by Windows.

In the case of connections that use an ethernet connection (e.g. cable or router connections), the KPI Pack software is able to interrogate the telnet or web-based administration interfaces of the device to capture connection speeds and other metrics that the device exposes such as line characteristics.

For wireless connections, the KPI Pack software queries the device directly to record the radio conditions (Signal Strength etc) under which the connection has been made.

The sample below shows Connection Speed of ISPs in a Line Graph.



5.2 HTTP

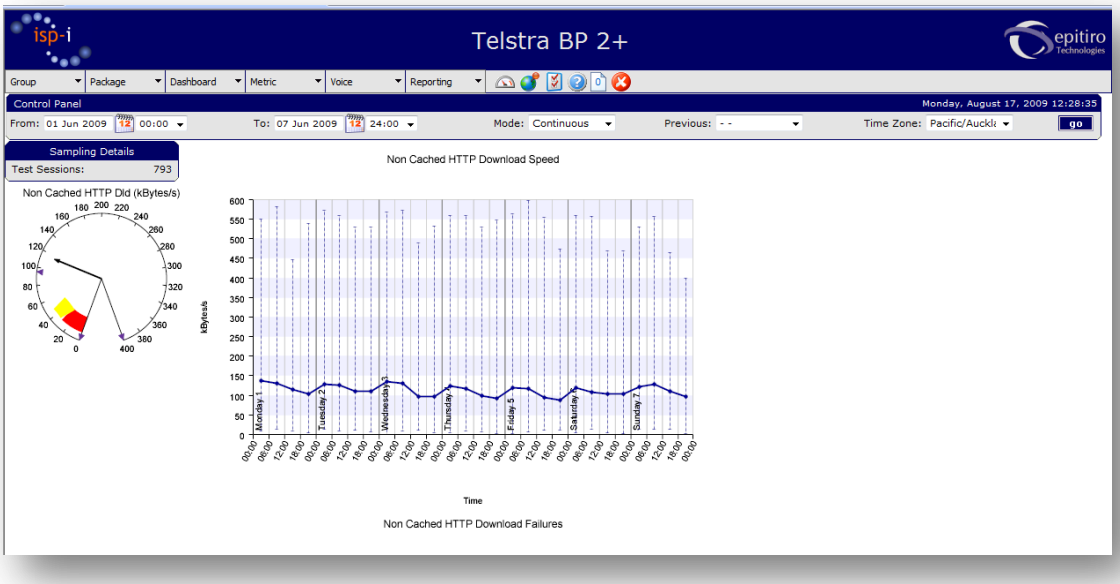
The HTTP test makes a request to the specified URL and records the time taken and the amount of data downloaded, from which the speed of the download is derived.

Depending on the configuration of the test, KPI Pack is also able to download the embedded content (e.g. images on a web page) in any HTML that results from the HTTP request. Any additional content downloaded is reflected in the captured timings and size of data downloaded.

Additionally, the HTTP test can be configured to run in one of two modes of operation: cached and un-cached. When the test downloads from the specified URL in "cached" mode, the speed of the download could be impacted by any caching mechanisms implemented by the network provider. The "un-cached" mode appends a random query parameter to the end of the URL, which will result in the request bypassing any caches present in the network, and the request will be serviced by the web server specified in the URL as opposed to any cache.

If a failure occurs then the HTTP status code is recorded. This can be used as an indicator as to whether the error resulted from the network or from a problem with the web server hosting the URL.

Below is a screen shot of a single ISP's Non-cached HTTP Download speed. The arrows on the dial to the left shows recent highs and lows as well as a threshold alert levels (yellow and red).



5.3 FTP

The FTP test is capable of performing a file upload and a download from the webspace (i.e. FTP server) provided by the service provider. The size of the file used for the test is dictated by the capabilities of the network connection and test configuration. When an FTP test is executed KPI Pack™ records the time taken and the amount of data downloaded or uploaded. From these results the speed of the FTP transfer is derived. If an error occurs during an FTP transfer, then KPI Pack™ records the last received FTP response code.

5.4 DNS

The DNS test records the time taken (in milliseconds) to resolve a fully qualified domain name to a corresponding IP address. The DNS servers used for the query are the DNS servers (primary and secondary) dynamically assigned by the service provider when the network connection is initiated. Alternatively a specific DNS server can be configured for use during DNS tests.

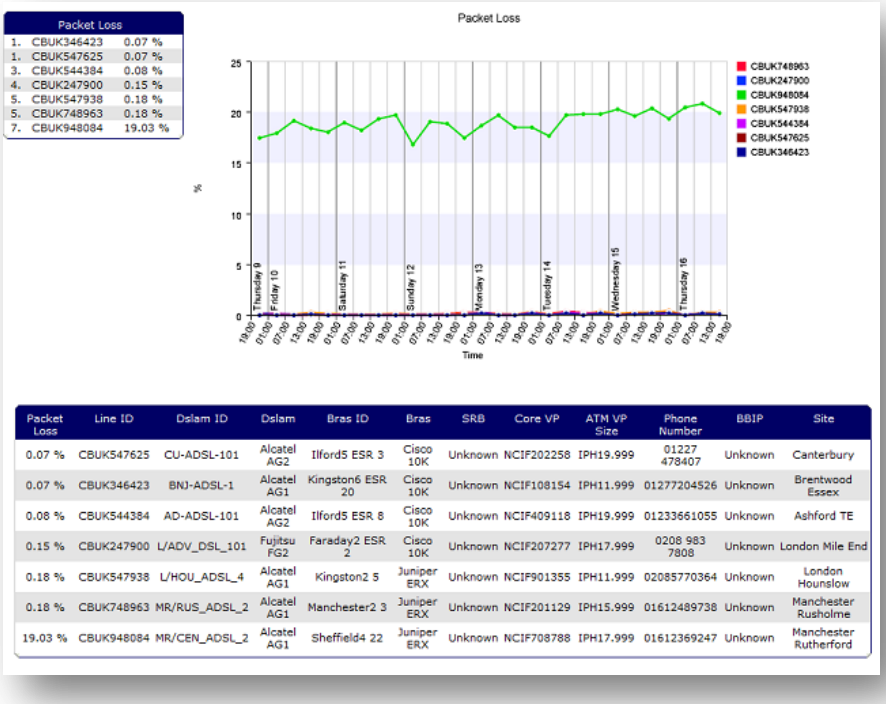
KPI Pack™ ensures that the DNS query is performed on the DNS servers, and not returned from any local cache, by disabling the Windows DNS Client Service responsible for caching the results of DNS requests.

5.5 Latency (Ping)

The Ping test measures network latency by sending an ICMP echo request to the specified server. The time recorded by KPI Pack™ is the total round trip time (in milliseconds) from the request to the echo response being received from the server.

5.6 Packet Loss – TCP Retransmissions

KPI Pack™ records the TCP Retransmissions during all the individual tests executed over the course of entire network connection during which the tests were being run. KPI Pack™ measures packet loss by utilising the Performance Counters for TCP available within Windows. TCP Retransmissions is recorded as the percentage of TCP segments transmitted from probes that contain retransmitted bytes.



Packet Loss	Line ID	Dslam ID	Dslam	Bras ID	Bras	SRB	Core VP	ATM VP Size	Phone Number	BBIP	Site
0.07 %	CBUK547625	CU-ADSL-101	Alcatel AG2	Ilford5 ESR 3	Cisco 10K	Unknown	NCIF202258	IPH19.999	01227 478407	Unknown	Canterbury
0.07 %	CBUK346423	BNJ-ADSL-1	Alcatel AG1	Kingston6 ESR 20	Cisco 10K	Unknown	NCIF108154	IPH11.999	01277204526	Unknown	Brentwood Essex
0.08 %	CBUK544384	AD-ADSL-101	Alcatel AG2	Ilford5 ESR 8	Cisco 10K	Unknown	NCIF409118	IPH19.999	01233661055	Unknown	Ashford TE
0.15 %	CBUK247900	L/ADV_DSL_101	Fujitsu FG2	Faraday2 ESR 2	Cisco 10K	Unknown	NCIF207277	IPH17.999	0208 983 7808	Unknown	London Mile End
0.18 %	CBUK547938	L/HOU_ADSL_4	Alcatel AG1	Kingston2 5	Juniper ERX	Unknown	NCIF901355	IPH11.999	02085770364	Unknown	London Hounslow
0.18 %	CBUK748963	MR/RUS_ADSL_2	Alcatel AG1	Manchester2 3	Juniper ERX	Unknown	NCIF201129	IPH15.999	01612489738	Unknown	Manchester Rusholme
19.03 %	CBUK948084	MR/CEN_ADSL_2	Alcatel AG1	Sheffield4 22	Juniper ERX	Unknown	NCIF708788	IPH17.999	01612369247	Unknown	Manchester Rutherford

5.7 Traceroute

Traceroute is a diagnostic test used to determine the route that packets take through the network to an endpoint, and to measure the network latency on the hops along the route taken. The KPI Pack™ Traceroute test uses ICMP packets and calculates the route by increasing the TTL (time-to-live) on each successive batch of transmitted packets. KPI Pack™ records the IP address (and resolved host name if available) of each hop on the route, along with the average round trip time for each hop from the ICMP echo request to the ICMP time exceeded response that results from the limited TTL.

5.8 Email (SMTP and POP3)

Email testing within KPI Pack™ consists of SMTP tests that run from a probe and POP3 tests that are run centrally to retrieve the emails from the POP3 mailboxes.

The SMTP test executed by the probe can be configured to send an email using the service provider's SMTP server to one or more recipients. Each email sent can be uniquely identified from an ID transmitted in one of the email's headers. The probe records the time taken to send the email using the SMTP server, and also any SMTP error codes that result during the course of the conversation with the server.

The POP3 component of the KPI Pack™ platform's email testing is performed from centrally managed servers that are configured to poll the mailboxes of each POP3 account once every minute. Whenever an email is retrieved that was sent from KPI Pack™, the time of retrieval is recorded. Any errors that occur while attempting to connect to a POP3 server are also recorded.

The polling servers use NTP to synchronize their system clocks with those of the probes. The combination of the timestamp of when an email was sent by SMTP (recorded by the AT400) and the timestamp of when the email was retrieved from its recipient's POP3 mailbox enables derivation of an email round trip time describing the total time taken for an email to be delivered to its recipient.

5.9 UDP Representative Stream Testing

UDP tests are initiated at a raw socket level from KPI Pack™ in order to test and characterize the delivery of UDP streams in terms of loss, jitter, latency and throughput. This is achieved by configuring the test to stream UDP data at a known rate (frequency and packet size) to and from a server endpoint (also running Epitiro software). The endpoint server is either hosted in a well peered Data Centre or located inside the network of the service provider being tested. The port over which the test is conducted and the duration of the test are also configurable settings.

During the test the levels of packet loss, jitter and latency are measured along with the achieved delivery throughput (relative to the configured delivery rate).

The UDP test can also be configured to test at rates that are representative of specific type of real-time traffic – for example streams of VoIP traffic using certain audio codecs or streams of real-time video. Where a representative test is configured (such as VoIP), an E-model MOS score (ITU G.107) can be derived from the packet level measures.

5.10 TCP Throughput – Line Capacity Testing

TCP throughput tests are initiated from KPI Pack™ at a raw socket level with the aim of testing the full capacity of the connectivity under test. This is achieved by configuring the test to initiate multiple TCP sessions and simultaneously use all open sessions for the transmission of data. The use of parallel TCP sessions enables the test to flood the connection and report a throughput that reflects the capacity of the line.

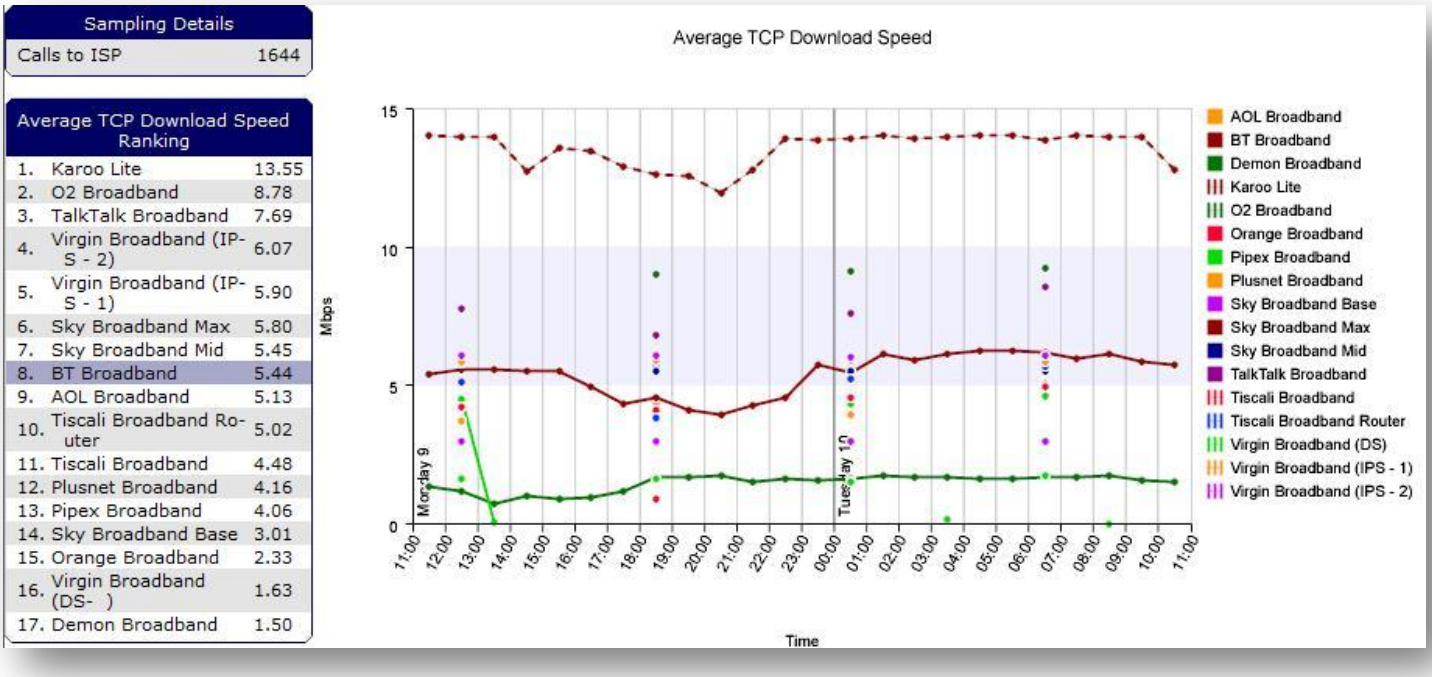
The test is typically conducted to a server endpoint (also running Epitiro software) either hosted in a well peered Data Centre or located inside the network of the service provider being tested. The port over which the test is conducted is configurable, but in most scenarios port 80 is used in order to minimize the possibility of the TCP traffic being managed or throttled during the test.

Once the test is connected data is transmitted upstream from KPI Pack™ to server and then downstream from server to KPI Pack™ in order to measure both upstream and downstream throughputs. Depending on whether the test is configured to be time bounded or byte bounded, data is either transmitted for a configured period of time or until a specified amount of data has been received.

KPI Pack™ records the time spent transmitting data upstream and downstream and also the amount of data received in each direction. The upstream and downstream TCP throughputs are then derived from these measures.

Sampling Details	
Calls to ISP	1644

Average TCP Download Speed Ranking		
1.	Karoo Lite	13.55
2.	O2 Broadband	8.78
3.	TalkTalk Broadband	7.69
4.	Virgin Broadband (IP-S - 2)	6.07
5.	Virgin Broadband (IP-S - 1)	5.90
6.	Sky Broadband Max	5.80
7.	Sky Broadband Mid	5.45
8.	BT Broadband	5.44
9.	AOL Broadband	5.13
10.	Tiscali Broadband Router	5.02
11.	Tiscali Broadband	4.48
12.	Plusnet Broadband	4.16
13.	Pipex Broadband	4.06
14.	Sky Broadband Base	3.01
15.	Orange Broadband	2.33
16.	Virgin Broadband (DS-)	1.63
17.	Demon Broadband	1.50



5.11 Voice (VoIP and PSTN)

The KPI Pack™AT400 is capable of both initiating and receiving voice calls to and from other AT400s within the KPI Pack™ network footprint. VoIP (Voice over IP) calls using SIP (Session Initiation Protocol) are supported as well as analogue calls over PSTN (see section **Error! eference source not found.** for details of required hardware) using Microsoft's TAPI interfaces.
In the describing and reporting the metrics that relate to Voice testing in KPI Pack, the terms upstream and downstream are defined as follows:

- Upstream – transmission of audio/data from the caller (initiator of the call) to the listener (recipient of the call)

- Downstream – transmission of audio/data to the caller, from the listener.

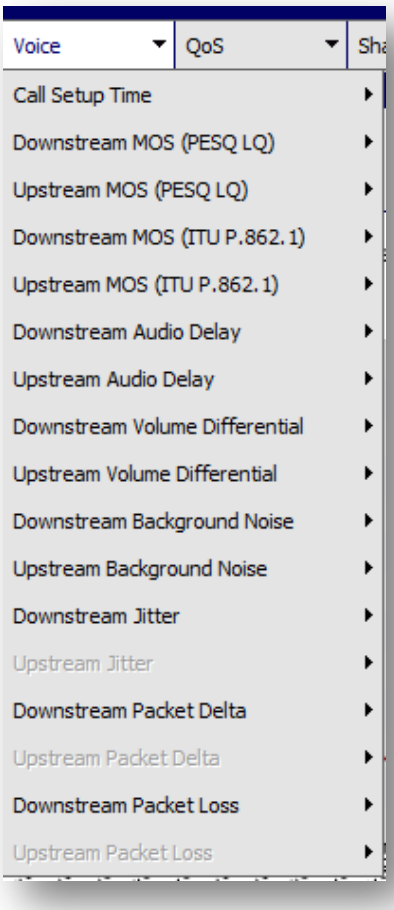
Prior to making a voice call, the KPI Pack™AT400 remotely negotiates with the AT400 that is to be the recipient of the call to ensure that it is ready to receive a call (i.e. it is connected – to the internet in the case of VoIP – and is not busy executing any other tests). If negotiation with the other AT400 is unsuccessful, then the calling AT400 will wait for a configured amount of time before retrying. Otherwise, after successful negotiation, the AT400 proceeds to initiate the call.

When making or receiving VoIP calls the KPI Pack™AT400 can be configured to use a specific audio codec and also supports DSCP marking in the Differentiated Services field of the IP packet headers that is often used to ensure that the VoIP traffic gets correctly routed and prioritised through the service provider's network.

Once a call has been successfully setup between the calling and receiving AT400s, the calling AT400 plays a reference speech signal upstream on the connected voice circuit to the receiving AT400 that records the incoming degraded audio. During playback of the reference, the caller also records the audio return for the purposes of echo analysis (see below). The same reference speech signal is then played downstream by the receiver and recorded by the caller. The receiver also records the audio return during playback. Once both caller and receiver have recorded a degraded audio signal and audio return, the call is terminated.

Upon termination of a successful call, the calling AT400 performs an analysis of the degraded audio signals (upstream and downstream). ITU standard PESQ is used to compare the degraded audio with the reference signal. PESQ (Perceptual Evaluation of Speech Quality) is an ITU-T standard (P.862) that provides an objective measure of speech quality over the connected voice circuit. An analysis is also carried out to look for unacceptable levels of echo that may be present in the recorded audio returns. Echo is determined to be unacceptable by comparing it to the echo tolerance curve defined by the ITU standard G.131.

The analysis of the degraded audio and audio returns, results in the following metrics being recorded for both upstream and downstream transmission:



- PESQ LQ MOS (Mean Opinion Score) on a scale from 1 to 5
- ITU P.862.1 MOS on a scale from -0.5 to 4.5
- Delay – delay introduced to the audio during transmission
- Volume Differential – the difference in volume between reference and degraded signals
- Background Noise Differential – the gain in noise present in the signal after transmission
- Unacceptable Echo Count (ITU G.131) – The number of instances of unacceptable echo during the call
- Echo Tolerance Differential (ITU G.131) – The difference in dB between the worst instance of echo and the tolerance curve described by G.131.

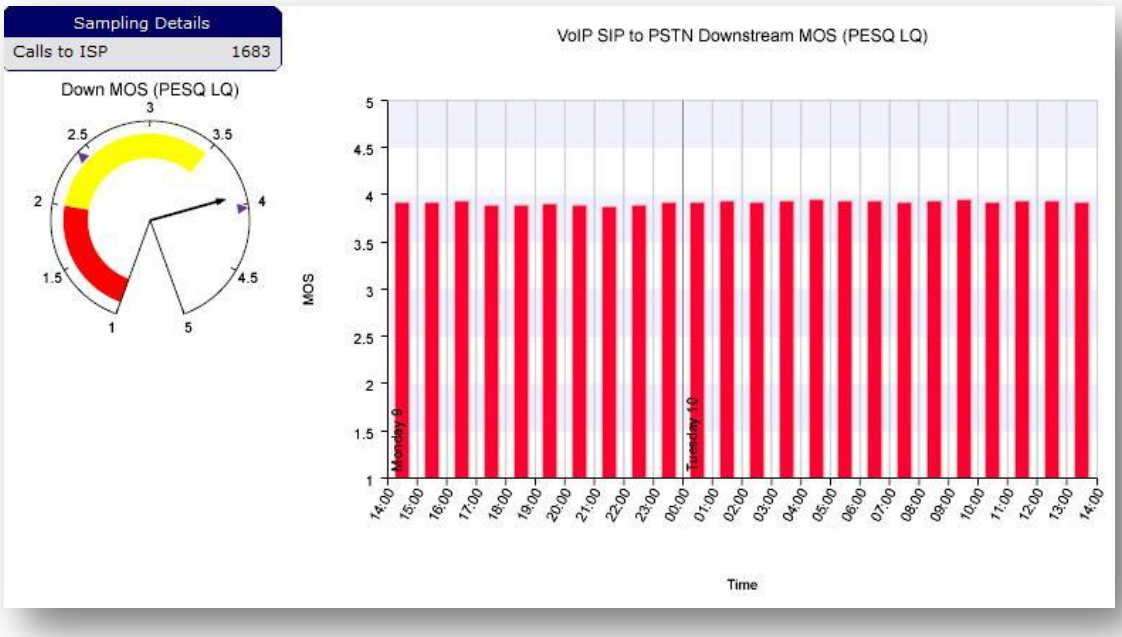
During the call, measurement of the network transmission of the audio data, results in the following metrics being recorded:

- Packet Delta – The arithmetic mean of the RTP audio packet inter-arrival time.
- Jitter – Estimate of the statistical variance of the RTP audio packet inter-arrival time. See RFC 3550 section 6.4.1.
- Packet Loss – The number of RTP packets that are not received, as detected by non-contiguous sequence numbers.

The three network transmission metrics described above are only available for test scenarios where VoIP endpoints are involved as follows:

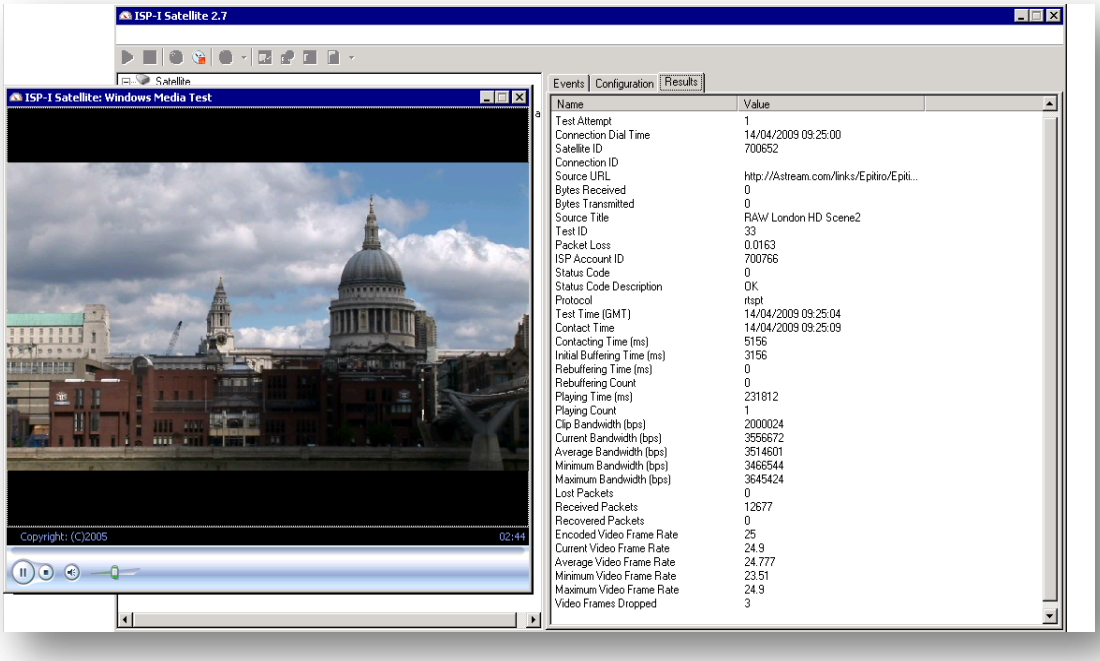
- VoIP to VoIP – Network metrics available downstream and upstream
- VoIP to PSTN – Network metrics available downstream
- PSTN to VoIP – Network metrics available upstream

The KPI Pack™ AT400 also records timings relating to the call setup (SIP based or analogue) and any errors that occur during negotiation, call setup, audio transmission or audio analysis. The KPI Pack™ dashboard reports on all of the metrics tested. Below is a sample Voice Quality screen using the ITU-T P.862 PESQ algorithm.



5.13 Streaming Media

KPI Pack™ supports live-playback and measurement of streaming media in both Windows Media and Real formats. The AT400 can be configured to stream video and audio from either a live or on-demand URL, for a specified period of time. Supported streaming protocol support includes RTSP, MMS, and HTTP.



The following key metrics are recorded during the course of the stream.

- Contact Time – the time to contact the streaming media server
- Buffer Time – initial buffering time required before playback
- Start-up time – the time taken to contact the hosting server plus the time taken buffering prior to the start of playback.
- Rebuffering – the amount of time spent rebuffering (relative to the amount of time in playback).
- Bandwidth – the average bandwidth achieved (relative to the bandwidth of the encoded stream).
- Application level Packet Loss and Recovery[7] – the number of lost/late/out of order/recovered packets (relative to the number of normally received packets).
- Maximum Bandwidth – Max rate achieved during sequence
- Minimum Bandwidth – Min rate achieved during sequence
- Frame rates – Average Minimum and maximum video frame rates achieved (relative to the frame rate of the encoded stream) during play-back
- Dropped frames – number or percentage of frames dropped during sequence
- Codecs – Video and Audio codec information and bit rates.
- CODEC encoding support can begin at 8Kbps and be incremented right up to HD rate (2Mb+)

Any errors that occur during setup or playback of the stream are also recorded by KPI Pack™.

6 Metrics by Probe

Metrics by Probe	AT400(M)	AT200	AT100	AT50	AT50M
Broadband Metrics					
Synchronization Speed	✓	✓			
HTTP D Speed	✓	✓	✓	✓	✓
FTP D/U Speed	✓	✓	✓	✓	✓
Traceroute	✓	✓	✓	✓	✓
DNS Resolution Time	✓	✓	✓	✓	✓
Ping Time	✓	✓	✓	✓	✓
Packet Loss	✓	✓	✓	✓	✓
Email Testing	✓	✓	✓	✓	✓
G.107 UDP Voice Quality	✓	✓	✓	✓	✓
G.1070 UDP Video Quality	✓	✓	✓	✓	✓
TCP D/U Speed	✓	✓	✓	✓	✓
Traffic Management	✓				✓
VoiceMetrics	✓				
Voice Call Setup Time	✓				
Voice Call Duration	✓				
PESQ MOS (Voice Quality)	✓				
Audio Delay	✓				
Volume Differential	✓				
Background Noise	✓				
Video Analysis Metrics					
Start-up time	✓	✓	✓	✓	✓
Non-playing time	✓	✓	✓	✓	✓
Re-buffering Time	✓	✓	✓	✓	✓
Bandwidth/Throughput	✓	✓	✓	✓	✓

(kbps)					
Delivered Bandwidth	✓	✓	✓	✓	✓
Delivered Frame Rate	✓	✓	✓	✓	✓
Frame Drops	✓	✓	✓	✓	✓
Location Metrics					
Longitude					✓
UTC timestamp					✓
Distance to Basestation *					✓
PSC					✓
Altitude					✓
Speed					✓
Bearing					✓
Radio Metrics					
Cell ID					✓
LAC					✓
Received Signal Strength					✓
SNR – Signal Quality					✓
RSCP					✓
Access Protocol					✓
BERT / BLER					✓
EC/IO					✓
Neighbouring Cell Info					✓
CQI					✓

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