# QMap
## IFC Experience Monitoring

> *"When passengers get on a plane, they want the same fast mobile broadband they get on the ground – and they want it on the smartphones, tablets and laptops they have with them."*
>
> – Inmarsat 2018 Inflight Connectivity Survey

## IFC Passenger Experience: Quality Matters

Airline passenger expectations for quality inflight Internet access are growing - and influencing their travel decisions. To remain competitive, airlines must meet or exceed these expectations for inflight connectivity (IFC). The first step is to know what passengers are experiencing. This requires measuring the actual in-seat connectivity experience from gate to gate—using that information to understand, manage, and tune your IFC service to ensure the best possible IFC experience.

### QoE versus QoS

While vendor-defined Service Level Agreements (SLAs) may be helpful to set expectations between a vendor and service provider, they only monitor the Quality of Service (QoS) of infrastructure along a specific portion of the overall path. In contrast, Quality of Experience (QoE) is measured at the individual seat level, and captures passengers' end-to-end experiences.



**Quality of Service**

QoS measures the point performance of individual infrastructure components along the data path (usually covered by SLAs)

# NetForecast®

## Quality of Experience

QoE measures the end-to-end experience from the passenger's device to their chosen destination on the ground
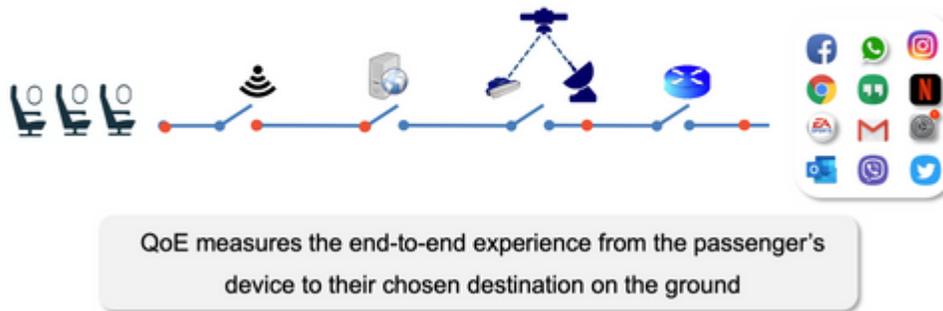
**Measuring the Passenger Experience**

Airlines routinely poll passengers about their inflight experiences, which although helpful, does not provide the actionable insights that hard data can deliver. Passenger quality of experience is best measured continuously, from end-to-end, using passengers' mobile devices, on regularly scheduled flights, and evaluated independently of the communications technology and vendors.
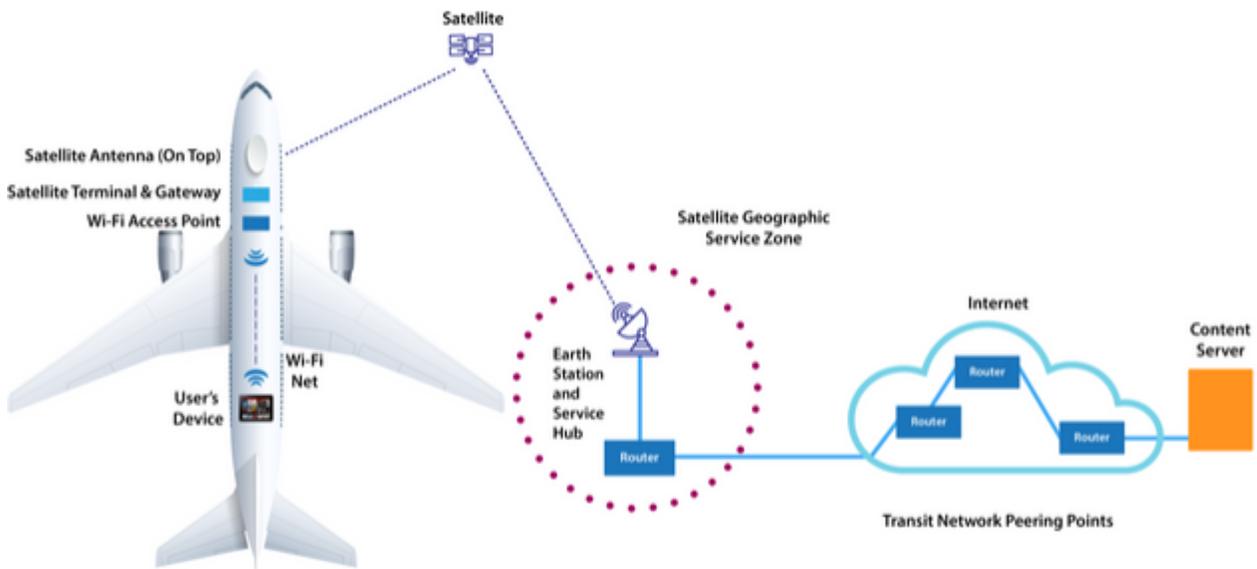


Accurately evaluating the end-to-end inflight connectivity experience requires a contextual framework that maps what passengers are doing on their devices to how network performance affects those activities.

NetForecast created the QMap Application Performance Matrix to map the sensitivity of application types to changes in five key network performance metrics. For example, a winning online game experience requires low network latency and high bandwidth, while file transfers and streaming applications can deliver acceptable experience quality under high latency and low bandwidth conditions.

| | | | Application Sensitivity to Internet Performance Metrics | | | | |
|---|---|---|---|---|---|---|---|
| | | | Packet Latency | Packet Loss | Packet Jitter | DNS Response | Effective Bandwidth |
| **Application Categories** | **Request-Reply** | **Messaging** (txt msg, WhatsApp, SnapChat) | Neutral | Neutral | Neutral | Low | Low |
| | | **Interactive** (Single player games, shopping, email) | High | High | Neutral | High | Low |
| | | **Virtual Desk** (Office360, Google Docs, VPN) | High | High | Neutral | Neutral | Low |
| | | **Multi-Player Gaming** (Fortnite, etc.) | High | High | Neutral | Neutral | High |
| | **Continuous** | **File Transfer** (s/w updates, backups, photo uploads) | Low | Low | Neutral | Neutral | High |
| | | **Streaming** (Netflix, Hulu, YouTube, Prime, Spotify) | Neutral | High | Neutral | Neutral | Low |
| | | **Social Media** (Facebook, Instagram, Twitter, Reddit) | Low | Low | Neutral | Low | Low |
| | | **Real Time** (Video conferencing, Facetime) | Low | High | High | Neutral | Low |

**Legend:** ☐ Neutral – no or negligible QoE impact  ☐ Low – moderate QoE impact  ☐ High – noticeable QoE impact

**Applications**: Passengers' applications fall into two broad categories based on the demands they place on the user-to-server communications path: **request-reply** and **continuous**. These two application categories share behavioral characteristics and their users share generally consistent expectations.

To function well, **request-reply applications require "responsiveness"** (e.g., the next screen starts to appear when expected), while **continuous applications require "flow"** (e.g., content continues to appear smoothly). The request-reply and continuous application groups include the types of applications described in the tables below.

## Request-Reply (responsiveness-centric)

| Application Type | Examples |
| --- | --- |
| **Messaging**................. | Text messaging, Skype text, WhatsApp, Messenger (Facebook), Slack, Snapchat, etc. (generally all asynchronous text-based communications) |
| **Interactive**.................. | Web, shopping, email, Gmail, single-player games (casino, strategy), etc. (typically browser-based, html, JavaScript, or client-server) |
| **VPN**............................ | The process of establishing and maintaining connectivity to a corporate or consumer VPN access to services [Note: this metric applies to the "tunnel", not the applications traversing the VPN] |
| **Virtual Desk.**.............. | Microsoft Office 365, Google G-Suite, corporate VPN access, remote SAP, etc. (aka virtual desk infrastructure (VDI)) |
| **Gaming**...................... | Multi-player real-time games like Fortnite, etc. |

## Continuous (flow-centric)

| Application Type | Examples |
| --- | --- |
| **File Transfer.**............... | Software updates, backup, photo uploads, etc. |
| **Streaming**................... | Netflix, Hulu, YouTube TV, Amazon Prime videos, YouTube, Pandora, etc. |
| **Social**.......................... | Facebook, Instagram, Twitter, Reddit, etc. |

**Network Performance Metrics:** Five network performance metrics, **latency, loss, jitter, DNS lookup**, and **effective bandwidth**, are critical to measuring application performance. Variations in each of these metrics affect the user experience within the application categories differently, and application types have varying degrees of sensitivity to changes in the metrics. For this reason, single metrics such as "speed" are insufficient to measure the true passenger experience. Below are descriptions of the five key network performance metrics.

| Performance Metric | Description |
| --- | --- |
| **Latency**........................ | Latency is the round-trip time (RTT) for a packet to travel from the device to the server and back to the device (not necessarily the same packet on the return). Applications incorporate many RTT events. A web page is "built" by the browser following a script of HTTP Gets that cause content to be displayed in reply. Each Get and reply is an RTT. A typical web page requires dozens of RTT events. |
| **Loss**............................ | Loss refers to packets lost during an RTT event or TCP flow. Packets may be lost traveling from device to server or server to device in any segment of the end-to-end communication and need to be retransmitted. Lost packets are costly to overall response time and can add unproductive traffic to the connection. |
| **Jitter**............................ | Jitter is the variation in one-way network transit time. Some applications such as multicast depend upon predictable transit time to perform well. |
| **DNS Lookup**................ | Most Internet site connections begin with a query to the Domain Name System (DNS). The user's browser or application must ask for a name-to-address resolution (like a phone number lookup) to the DNS. |
| **Effective Bandwidth**... | Effective bandwidth is the number of bits per second (bps) successfully transferred from sender to receiver. If an application response requires a large amount of data, more bandwidth (i.e., connection capacity) will enable the content to move faster. |

It is not necessary to know the absolute best values for each network metric. If an application category is providing satisfactory performance, the network metric values are good enough to support baseline performance, and we can deduce that the passenger experience is satisfactory. Application performance deteriorates when the network metrics degrade from the baseline performance. The QMap Application Performance Matrix maps the sensitivity of each application category to degradation in each of the network metrics.

## QMap IFC Experience Monitoring

NetForecast's QMap IFC Experience Monitoring performs active tests from an application installed on passengers' mobile devices. The QMap application captures end-to-end latency, loss, jitter, DNS lookup, and effective bandwidth data throughout participating passengers' flights. During periods when passengers are connected to the Internet, the QMap mobile application continuously uploads performance and contextual data (e.g., flight location and altitude) to the QMap analytics engine, which creates near real-time reports and dashboard views of end-to-end IFC performance.

The QMap dashboard provides visibility into massive amounts of user experience data, enabling network service providers and system vendors to quickly ascertain the location of performance issues and resolve them.

NetForecast's QMap analytics engine documents the passenger's in-seat experience by application type and applies intelligence about the application type's sensitivity to network performance in order to rate the user experience. For example, a satisfying online game experience requires low network latency and high bandwidth, while file transfers and streaming applications can deliver an acceptable experience under high latency and low bandwidth conditions. Knowing this enables network service providers and system vendors to deliver the best possible performance for the applications that are typically important to passengers while in the air.
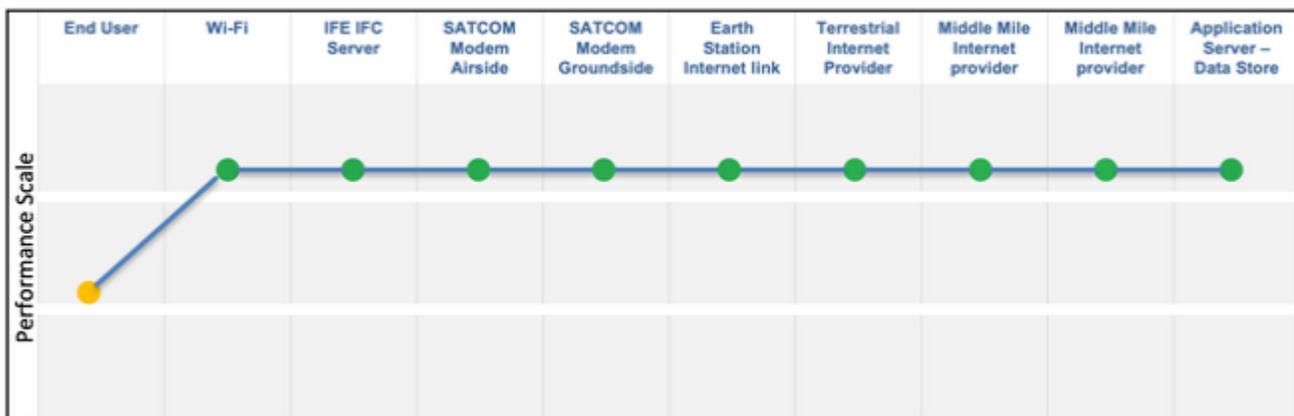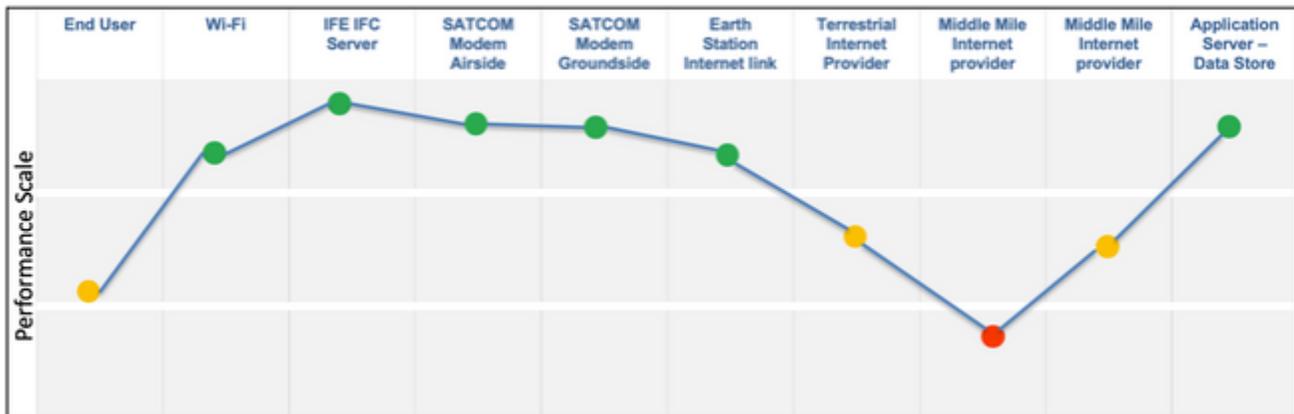
NetForecast monitors the first, middle, and last miles of the passenger's experience. Although attention is usually focused on the access portion of the network path, when passengers complain that their IFC service is slow, they may be reacting to degradation of the middle mile (the Internet itself) rather than the first mile (access) or server (content source). Middle mile performance incidents routinely impact the user experience. The middle mile is complex, involving a dynamic set of peering points, content delivery networks (CDNs), and transit backbone operators. In such a complicated environment, performance issues are inevitable, and tracking them down is difficult.

QMap tests middle mile performance, enabling proactive detection and correction of peering and related issues before they adversely affect passenger satisfaction. NetForecast applies a network tomography approach that not only discovers, but also quantifies, middle mile performance incidents. This valuable information is not available from other sources.

## Why NetForecast

Data networks are dynamic systems in which change is the rule, not the exception. The only way to understand the behavior of a complex, ever-changing network, and its impact on the passenger experience, is to dynamically and independently monitor it—from the users' point of view using the applications they use. This is what we do.

With decades of experience designing, measuring and assessing network performance across most major U.S. NSPs, we help service providers get to the root cause of customer impacting performance issues to improve quality of experience, enhance customer satisfaction, advance competitive position, and strengthen the bottom line.