SEAMLESS

AIR ALLIANCE

SLA BUILDING BLOCKS

BEST PRACTICES TO MEASURE IFC PASSENGER EXPERIENCE

Copyright Notification

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1.INTRODUCTION

Inflight connectivity (IFC) enables airlines to offer passengers internet access.

Managed service providers (MSPs) operate end-end IFC networks comprising of a large portfolio of equipment and services such as:

- Onboard Wi-Fi access to passenger devices
- Onboard head-end servers hosting cached content and passenger/crew applications
- Onboard routers, switches and interconnecting networks
- Onboard IFC radio terminal with modem and antenna
- Air-ground IFC radio network (typically, satellite based) with teleports and hubs
- Terrestrial interconnecting networks
- Cybersecurity applications
- Traffic-shaping applications
- Application-filtering applications
- Internet point-of-presence (PoP)

The MSP is responsible for providing each IFC network element.

A traditional Service Level Agreement (SLA) can be applied to each IFC network element with basic quality of service (QoS) parameters such as availability, reliability, and performance attributes that must customized for each element, in a piecewise manner. The Seamless Air Alliance Open IFC Toolkit provides a compendium of these aspects.

The IFC quality of experience (QoE) for passengers is based on the performance of their personal device with client applications that are tied to application servers connected via the internet.
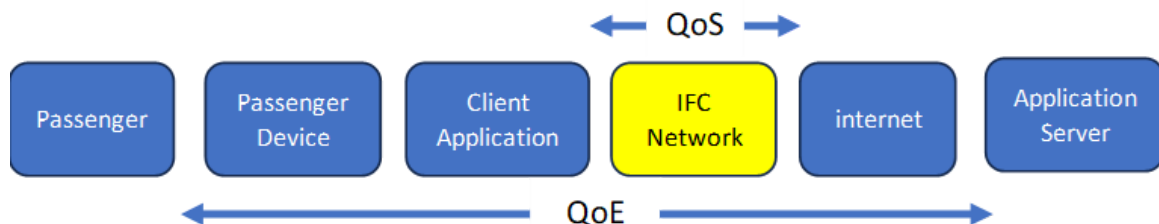
An SLA applied to IFC QoE requires special considerations to account for the many components outside of the scope of the IFC network, notably the passenger device and applications, the internet, and the application server. Passenger experience is affected by IFC network QoS but cannot be guaranteed solely by IFC QoS. Application-specific measures are needed to represent each application's performance. For example, browsing and streaming emphasize different aspects of IFC network performance.

Standardization of QoE measures allows airlines to judge passenger experience across different IFC networks. Standardization of QoE scoring provides a foundation for managing passenger experience and setting passenger expectations.

1.1 Background and Mission

The Seamless Air Alliance (SAA) was formed as a non-profit organization in 2018 by Airbus, Delta, OneWeb, Sprint and Airtel. SAA facilitates industry-wide collaboration between leading airlines, service providers, equipment suppliers, and others. SAA reports and standards drive understanding, innovation, economy, and flexibility. The SAA empowers airlines to build agnostic systems that connect to a marketplace of providers for inflight connectivity technology and services.

SAA members envision a seamless and secure inflight connectivity experience that will enable personalized customer engagement opportunities for airlines, extend Mobile Network Operator roaming relationships, while providing managed, measured, and reliable internet access from gate-to-gate.

1.2 SAA Expert Working Groups

The SAA is a robust organization based on a set of working groups, which are composed of world-class experts in the telecommunications and aviation connectivity fields. These experts are affiliated with the most important companies and organizations in the aviation industry, including airlines, airframe manufacturers, inflight connectivity service providers, satellite operators and equipment manufacturers.
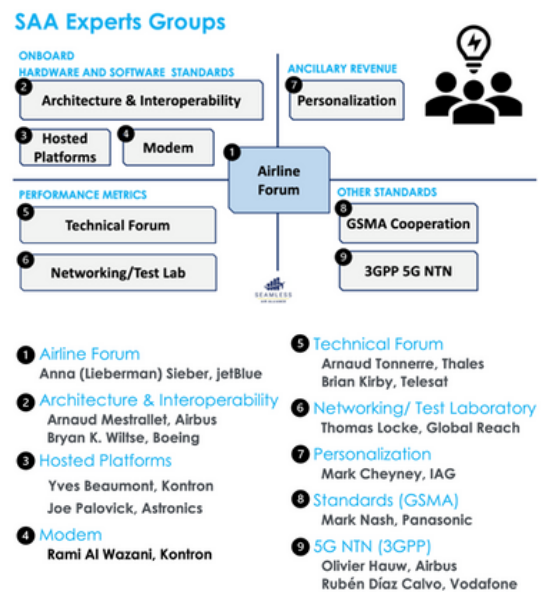
Figure 1 - SAA Working Group structure and industry chairs

1.3 Airline Forum and Tech Forum

The Seamless Air Alliance has been focused on measuring and managing the IFC experience through the efforts from a combination of the Technical Forum and Airline Forum. The Technical Forum focuses on defining measurements and proposing associated experience scoring thresholds. The Airline Forum promotes airline priorities and preferences and collaboratively validates SAA group objectives and products.

1.4 Contributors

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2. EXECUTIVE SUMMARY

Airlines and Managed Service Providers (MSPs) work together to set inflight connectivity (IFC) service level agreements (SLAs) that match their business objectives.

Remedy is a necessary element to any SLA. Remedy should motivate restoring service levels to meet SLA. Continuing remedy should escalate penalties and have an exit clause in dire circumstances.

Network Quality of Service (QoS) SLAs are sufficient to manage the IFC network. Network QoS cannot reliably predict IFC Quality of Experience (QoE).

Seamless Air Alliance Certified program offers a standardized approach to measuring and scoring network QoS and IFC QoE.

The Seamless Air Alliance test laboratory is used for setting satisfaction scoring levels for any IFC network. The Seamless Air Alliance has developed a controlled web site and streaming content that should be used for browsing and streaming IFC QoE measurements.

IFC QoE SLAs are necessary to manage the passenger experience.Application-specific IFC QoE scoring is necessary, with at least a weighted session score for browsing and a score for streaming.

Latency limits browsing satisfaction levels over GEO satellite networks. Only LEO/MEO satellite networks can deliver a home-like IFC browsing experience.

Any IFC network could deliver a home-like IFC streaming experience. Forward channel data rate scales with video resolution.

Airline and MSP should agree on satisfaction levels for each category along with expected streaming resolution.

2.1 Acronyms

Acronym	Definition
DPI	Deep-Packet Inspection
GEO	Geostationary Earth Orbit
IFC	Inflight Connectivity
LEO	Mid-Earth Orbit
MEO	Mid-Earth Orbit
MSP	Managed Service Provider
PoP	Point of Presence
QoE	Quality of Experience
QoS	Quality of Service
SAA	Seamless Air Alliance
SLA	Service Level Agreement
WAP	Wireless Access Point

3. WHY AIRLINES WANT A SERVICE LEVEL AGREEMENT (SLA)

Airlines are in the business of transporting passengers (users, guests) from a departure airport to a destination airport. Every airline offers passengers products and services to enhance their inflight experience. Inflight connectivity (IFC), connecting a passenger device to the internet, is a prominent passenger service offering. IFC involves a contract between an airline and a IFC managed service provider (MSP).

> *"The whole passenger experience is equated to the airline brand, not to the internet service provider. In the end, the airline takes the bigger hit, reputation wise. Most customers don't know enough to be able to separate the two."*
>
> ***Anna Sieber, JetBlue***

IFC is a complex service with many components. IFC performance is influenced by factors within the Wi-Fi network, the backhaul radio network and teleport, and the internet point of presence (PoP).

A service level agreement (SLA) is a contract between and airline and an MSP with agreed upon measurements, thresholds to judge each measurement, and a plan for remedy if performance is inadequate. An SLA takes marketing claims and turns them into reality.

> *"Procurement needs SLA as a standard piece of the contract to ensure that they can hold those suppliers accountable to the service that they've contractually agreed to deliver to us."*
>
> ***Airline Forum Member***

An airline is interested in controlling those factors impacting the airline ecosystem, notably their costs relating to maintenance and management of the IFC system, and passenger experience using the IFC service. An airline is not interested in every facet of an IFC system. An IFC SLA is mostly applied to the high-level airline factors.

An SLA around maintenance and management of an IFC system is straight-forward, solely with airline and IFC participation in well-defined workflows and expectations.

> *"Getting a precise understanding of capacity when signing a contract with a new provider is essential. What is it going to look like across the duration of the contract time? How will things change if they sign on new business partners? All kinds of moving targets affect these measurements!"*
>
> **Anna Sieber, JetBlue**

A network performance SLA is focused upon the backhaul radio network, from onboard terminal to teleport. Assessing network performance is well understood, with the MSP in control of all nodes, conducts all measurements, and prepares all reports.

An SLA around passenger experience is inherently complex. Every passenger has a unique combination of user device and applications connected to a unique combination of application and content servers. Each application performance is judged uniquely by every individual.

> *"An SLA provides a basis for a discussion. How can you expect to discuss poor performance if you've not defined in the contract certain numbers and measures to tell if a service is good or bad? If you've not got anything as a starting point, we all dig our heels in and say, that's your view, quote unquote."*
>
> **Floris Reimbold, Lufthansa**

Airlines are keenly interested in passenger experience, QoE. The MSP controls the IFC network QoS. The MSP does not control the user device, the user applications, the internet, or the application and content servers. QoS inherently relates differently to each application-specific generic IFC QoE, while each user adds another dimension.

An IFC QoE SLA between an airline and MSP offers reliable and relevant proxy scoring for significant applications, such as browsing and video streaming. Each airline and MSP can agree on the target level for each application-specific IFC QoE in their SLA, which can be applied to any IFC network.

An airline choosing to purchase IFC network capacity may rely solely on network QoS SLA with their MSP. However, the airline will still need to use IFC QoE measurements for directing network settings.

An airline choosing to purchase IFC sessions benefits from IFC QoE standards to ensure passenger satisfaction throughout the lifetime of the MSP service contract.

4. REMEDY

A service level agreement inherently must address remedy, the consequences from failing to meet the SLA. The SLA must be very specific to what is considered a shortcoming and how remedy is to be applied is such a circumstance.

> *"You must anticipate any sort of SLA breaches in order to have a plan if that happens. I don't think we should ever assume that any IFC supplier is going to be able to provide top notch performance all the time."*
>
> **Anna Sieber, JetBlue**

Remedy is way to payback the airline for a shortcoming.

> *"No airline wants to get SLA penalty payments at all. No airline wants to have the additional money because of the lost reputation on the passenger side. Unhappy passengers are much more severe than any payment that you would get out of such a penalty clause."*
>
> **Floris Reimbold, Lufthansa**

An airline must balance remedy against the consequences from underperforming IFC as experienced by the passenger. An MSP is expected to take action to resolve any SLA shortcoming. The MSP is expected to understand what is causing the shortcoming and what it will take to correct it. In many cases, the causes may not be immediately apparent, as well the solutions. Time is of the essence as more and more passengers are let down.

> *"Our IFC supplier had underperformed its SLA for over a year. Each month we were getting the remedy, the commercial remedy, that was laid out in the contract."*
>
> **Airline Forum Member**

Remedy is never intended to become "a cost of doing business". Remedy is intended to motivate the MSP to rectify the shortcoming and comply with the SLA.

> *"What does happen if six months down the line, the SLAs continue to plummet?"*
>
> **Anna Sieber, JetBlue**

Remedy should include escalation, where the consequences become more and more significant until the SLA terms are met. Remedy should direct service provider investment to best maintain passenger experience.

> *"The service provider will just keep paying, and keep paying, and keep paying, and just move on. My hope is that the penalty is higher and greater, and it ultimately leads to the ability to cancel the contract. Instead of it just being a dollar amount, it becomes if you haven't met the service level agreements for an X amount of time or X period, it allows the airline to effectively terminate the contract with cause. Like a force majeure."*
>
> **Airline Forum Member**

Given that financial penalties will ultimately saturate, remedy must have a pathway to contract termination. Neither the airline nor the MSP would ever anticipate this situation arising, but the airline cannot be trapped either – there has to be an exit clause.

> *"It must be pretty dire to rip off equipment."*
>
> ***Airline Forum Member***

Remedy in the form of escalating financial penalties or other aspects is likely to be entirely confidential to an airline and its MSP. On the other hand, the IFC marketplace is generally aware of an airline terminating a contract with an MSP or shifting airplanes to another MSP.

> *"Financial penalties are one thing. The provider can just sweep that under the rug and keep paying. A bigger hit to their portfolio is if they end up losing contracts. It's a very small IFC community. It becomes very apparent if airlines start shifting away from certain companies."*
>
> ***Airline Forum Member***

An SLA must relate to the passenger experience, and that relationship must be validated. SLA shortcoming will lead to an airline losing reputation with its passengers. Remedy "escalated to termination" will lead to an MSP losing reputation with airlines.

5. SEAMLESS AIR ALLIANCE OPEN IFC TOOLKIT

The Technical Forum released the IFC Toolkit in 2022. The IFC Toolkit is a set of documents, EXP-0 through EXP-12. Each document focuses on one "segment" of the IFC network, as well user device and application server.

Number	Topic
EXP-0	Master IFC EXP Program
EXP-1	Measuring Specific Application Service Quality
EXP-2	Measuring Web Browsing Service Quality
EXP-3	Measuring Streaming Service Quality
EXP-4	Measuring Wi-Fi Networking Service Quality
EXP-5	Measuring Backhaul Networking Service Quality
EXP-6	Measuring Portal Service Quality
EXP-7	Measuring User Device Service Quality
EXP-8	Measuring Application Server Service Quality
EXP-9	Measuring Wi-Fi AAA Service Quality
EXP-10	Measuring IFC Product AAA Service Quality
EXP-11	Measuring IFC Platform Quality
EXP-12	Quality Control Agent

Each EXP document is applied to one segment of the IFC user journey, from connecting to the onboard Wi-Fi, activating an IFC session, using IFC, and the accounting afterwards. EXP-5 (backhaul) spans several segments across the journey. EXP-12 Agents are applied along those segments involving the IFC service experience. EXP-11 (platform) is applied to every segment.
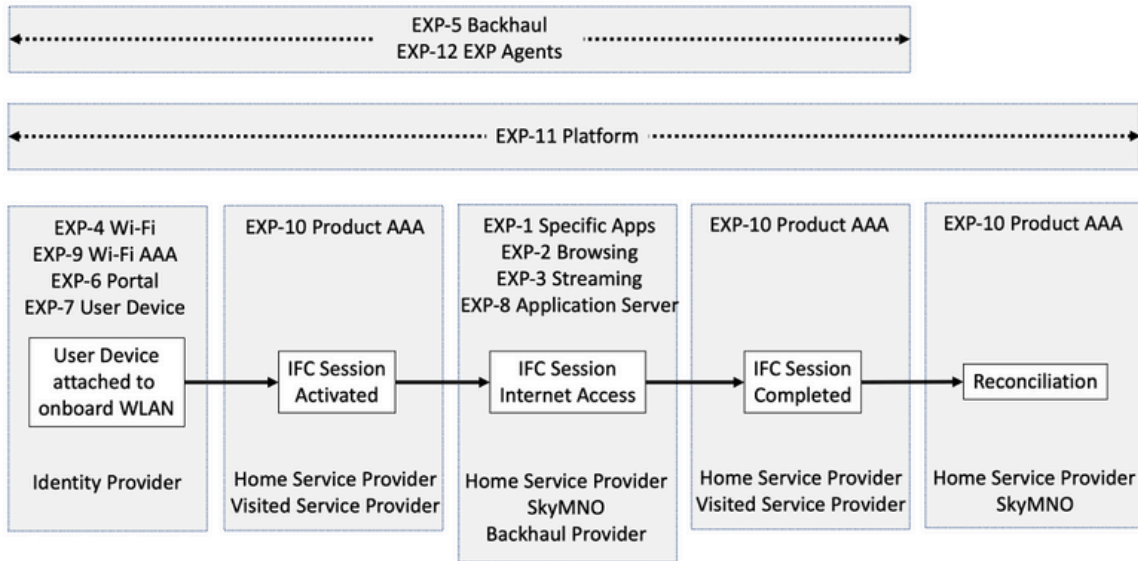
EXP-1, EXP-2, and EXP-3 developed concepts around end-end internet service quality of experience (QoE). EXP-12 provided for an onboard agent to measure service quality as if another passenger (n+1). Other documents focus on other aspects that can be considered quality of service (QoS).
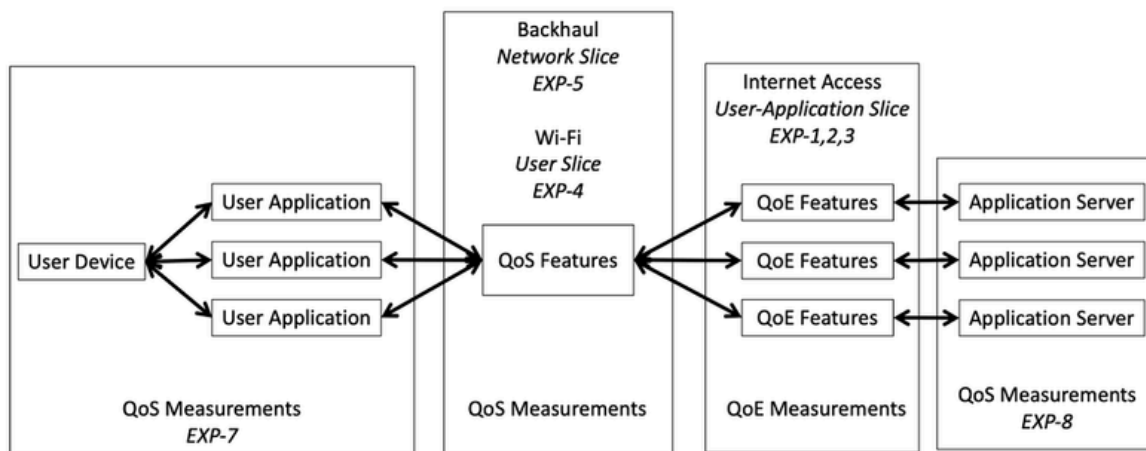
The IFC Toolkit provides a superset of over 550 items for measuring and managing all aspects of an IFC system. The IFC Toolkit remains a foundation for any service level agreement based on measurements and for negotiating IFC features for managing the service.
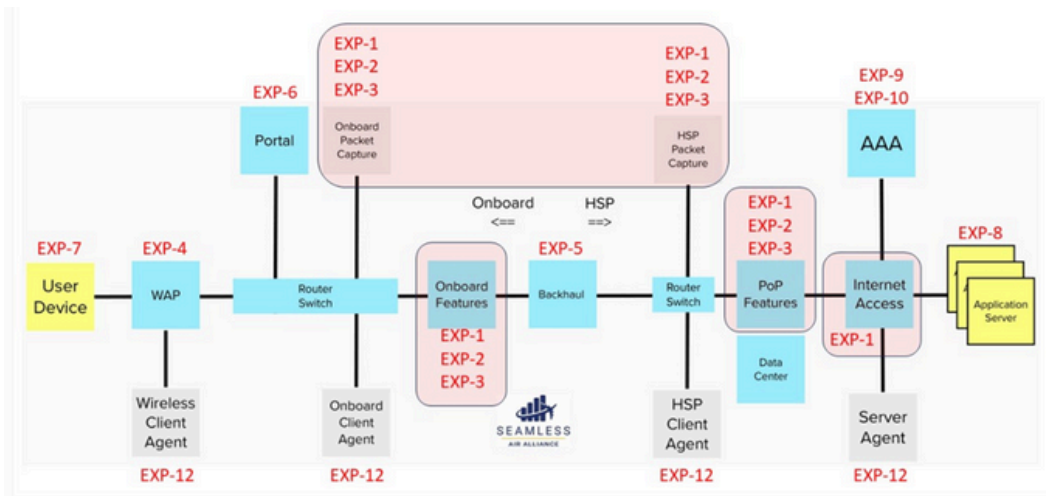
The Technical Forum collected EXP-1 (specific applications), EXP-2 (browsing), and EXP-3 (streaming) measurements into a subset that would comprise QoE assessment.EXP-12 provided nodes for agent-based methods to conduct the measurements. Deep Packet Inspection (DPI) methods through packet capture were not found to be suitable, yet interest continues in these passive measurements.

The Technical Forum produced the Seamless Certification Program in 2023 to encourage managed service providers to provide airlines with standardized IFC QoE measurement methods, scaling and scoring. The Airline Forum worked in lockstep with the Technical Forum to ensure the need and application of each measurement.

The program's 13 measurements assess network performance (Q0S), browsing performance (QoE) and streaming application performance (QoE). Thales Avionics achieved Seamless Certification at the outset.

The Technical Forum and Airline Forum had many lessons-learned in the (ongoing) journey to IFC QoE measurements and scoring, many of which are described in this document. The Seamless Air Alliance is the only standards body dedicated to IFC. The collaboration and consensus between SAA members from all sides of the IFC table ensures that these QoE measurements are the most relevant to any IFC SLA assessing passenger experience.

6. BENEFITS OF AN INDUSTRY STANDARD FOR IFC QOE VERSUS LETTING EVERY SERVICE PROVIDER SET THEIR OWN STANDARD

Interestingly, each MSP may represent different levels of network performance as being adequate. How much data rate on the forward and return channels to each airplane? What about the data rate to a user device? One MSP will guarantee one data rate as being adequate while another MSP may recommend a very different data rate for the same service. An airline may have difficulty reconciling differences in SLA between MSPs offering the same service. MSP customized application filtering and traffic shaping features are difficult to account for within network SLA.

"Our network SLA uses the same formula across all our connectivity providers. That's great that, that we've got that, but that's only a network SLA."

Airline Forum Member

Certainly, network QoS is a factor in IFC QoE. But each IFC specific application represents a different network performance profile. Inherently, network QoS cannot solely predict IFC QoE.

MSPs contract with multiple airlines. Airlines may contract with multiple MSPs. Each of these agreements has typically entailed a customized QoS SLA and remedy. Without standards, each SLA may be unique in both the types of measurements and associated thresholds.

The Seamless Air Alliance has developed standards for network QoS and IFC QoE through the work of both the Airline Forum and the Technical Forum.

A standardized approach to both network QoS and to IFC QoE can simplify both the MSP tasks and airline acceptance. A standardized approach can allow direct comparison regardless of IFC network. A standardized approach can ensure that the SLA is comprehensive. A standardized approach can represent industry consensus.

7. HOW DO SERVICE PROVIDERS RELATE TO SLA (STANDARD VS BESPOKE)?

Every IFC MSP represents that their service offering will please passengers. An airline must be confident that the MSP will deliver on their promises. Naturally, MSPs are prone to minimize SLA measurements and remedy. Traditionally, IFC SLA have focused solely on network QoS.

> *"Your customer satisfaction says one score, yet your SLA says another score."*
>
> **Airline Forum Member**

The airline and the MSP must find an SLA that relates to IFC QoE.

Each MSP has their own perspective of IFC QoE. Some will insist that artificial intelligence applied to network QoS can be equivalent. Some will favor machine learning applied to deep-packet inspection (DPI). Some will promote the use of agents with scripts that test against a variety of web sites and content providers. While all these methods have merit, it becomes impossible for an airline to compare the MSP-customized measurements between MSPs. Furthermore, a careful process must be applied to determine how well each of these customized measurement correlates to IFC QoE. MSPs may be unwilling to share their confidential algorithms. Airlines cannot agree to SLA terms based on confidential algorithms.

The Seamless Air Alliance Tech Forum, with MSP representation, works with the Airline Forum, with airline representation, to develop IFC QoE standards. An open, collegiate approach with consensus decision making gives a voice to all parties, enabling a balanced solution for both airline and MSP.

8. WHAT ARE THE KEY MEASUREMENTS FOR NETWORK QOS AND IFC QOE?

Inflight connectivity connects a passenger's device via onboard Wi-Fi to the internet via a broadband radio (satellite radio, predominantly). A portal provides access to onboard web services, including access to inflight entertainment. Internet access involves a terrestrial point-of-presence (POP), the internet itself, and application servers.

For the purpose of this document, quality of service (QoS) applies to the performance of IFC network, from the user device to the internet POP. Quality of experience (QoE) applies to the internet access service, from the user device all the way to the terrestrial application server.

QoS is defined around availability, reliability, latency, packet drop, and data rate. QoS can be applied independently to the forward channel (transmit data to the user device) and to the return channel (receive data from the user device).

QoE is defined around specific applications. Each application requires a unique test. For example, browsing applications focus on how quickly and reliably the web page is rendered to the user. For streaming, the focus is on a quick and smooth playback experience.

QoS methodologies are somewhat constrained to live within the MSP enterprise, with every node under their direct control. QoS measurement methods and scaling may be predictable and stable.

QoE methodologies include aspects outside of MSP direct control, notably the internet, application servers, and content providers. These external aspects can greatly influence QoE measurements. A single web site can be presented very differently depending on the internet PoP. A single web site can change manifestly over time, by content and layout, such that it may load very differently without any networking change.The same video title at the same resolution may require very different data rates depending on the content provider.

It is possible to utilize a control agent to monitor any external element being used for QoE measurements that can be used for relative measurements made onboard, the IFC transfer function. However, this alone adds significant complexity and uncertainty.

Having explored each of these avenues, the Seamless Air Alliance Tech Forum concluded that a reference web site and streaming content offers the only repeatable method for measuring IFC QoE. Furthermore, the references allow for minimizing network burden while under test.

9. HOW DO THE IFC QOE MEASUREMENTS RELATE TO NETWORK QOS?

Web browsing between a client browser and a web server is highly transactional. A web page is rendered through a sequential process to retrieve and activate specific elements. As latency increases, so does the time for each transaction to complete, extending the time to render the web page to the user.

Seamless Air Alliance testing has demonstrated a strong correlation between network latency and browsing performance. The longer the latency the poorer the browsing performance.

Latency is the time for a message (datagram) to be sent and a response received. Terrestrial networks can achieve less than 10 msec latency between a client and a server communicating over the internet.

Satellite communication adds additional latency given the need to span the distance to the satellite twice.

Low Earth Orbit (LEO) satellites operate near to the Earth. Mid Earth Orbit (MEO) satellites operate further out than LEO. Geostationary Earth Orbit (GEO) satellites operate much further out than LEO. Typical latency for LEO is less than 100 msec, for MEO less than 200 msec, and for GEO about 650 msec or more.

Congestion can significantly extend latency on any network due to queuing and retries.

A recent report[1] on latency relating to IFC showed a single web page could take two to three times as long to load over "typical GEO latency" as compared to "typical LEO latency".

Seamless Air Alliance Tech Forum testing on multiple websites, including cached versions of websites, confirmed a clear trend between latency and diminished web browsing performance. Seamless testing also shows that GEO-like latency can take twice as long, or longer, to load as compared to LEO-like latency. Increasing data rate did not resolve this difference.

Seamless Air Alliance Tech Forum testing on multiple streaming content providers demonstrated differences in resolution for the same data rate, presumably by differences in their streaming encoding processes. Increasing the forward channel data rate drives higher and higher resolution. Latency did not have a profound impact to the viewing experience once the title began to playback.

[1] https://www.netforecast.com/wp-content/uploads/NFR5151_IFC-Latency-Report_May-2024.pdf

10. HOW TO MINIMIZE NETWORK BURDEN FROM SLA MEASUREMENTS?

There are fundamentally two types of measurements available: deep-packet inspection (DPI) and agent-based applications.

DPI can be applied to network QoS by observing achieved network performance but does not stress the network to reveal maximum performance available.

Appling DPI to QoE involves analysis of an application data stream. Many companies have been able to associate source and destination addresses, routing, protocols, and data rate/volume to specific applications or application types. However, much of the payloads are fully encrypted, content distribution networks cloud the associations, and other factors dilute the ability to draw direct insights, such as when a web page loaded, what resolution a video title is running at, or whether buffering/stalling is encountered in streaming playback. DPI is best applied to application filtering and throttling features to enhance overall network throughput.

The only way to exercise an IFC network for IFC QoE measurements is to be able to operate within the dialogue between onboard client and internet application server. The agent can be applied at either end, albeit the client end is the most straightforward.

Agent-based measures are a proxy for user measurements. Each user makes their own choices as to applications and content. Agent-based measures do not reflect a specific individual's experience. Agent-based measures are consistent. DPI remains the best solution for assessing an individual user's experience. For now, DPI relates mostly to what the user is doing.

Network QoS measurements should be optimized for representative data rates. A smaller payload can exercise a constrained network, and a larger payload is needed for a more capable network. It is pointless to use a larger payload on a constrained network.

IFC QoE measurements can utilize minimal web site content and be directed to suitable video resolutions. Increasing the size of a web site does not increase the usefulness of a measurement compared to a smaller web site. What is most critical is to ensure the website exercises a full complement of element types and protocols. Limiting resolution to the maximum required has less burden than testing with higher and higher fidelity.

Orchestration features can manage when an agent conducts a test. The test schedule can limit the number of tests and intervals between tests to minimize test burden.
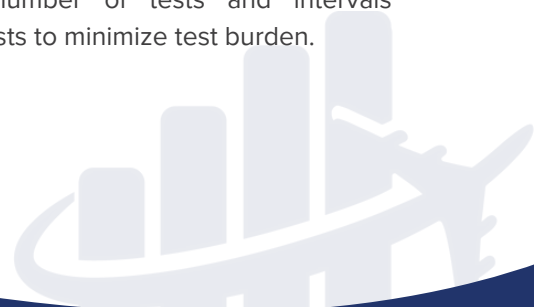
11. WHAT DOES THE AIRLINE WANT (DESIRED SLA SCORE)?

Every airline has their own level of financial commitment to passenger experience. Each airline must decide what level of IFC QoE matches their brand and budget. An airline may seek a different service level if free to the passenger Vs passenger pay as you go, or even across seat class or loyalty level.

Passenger Experience levels can rise and fall based on demand and available network capacity. MSP traffic shaping and throttling can change application performance. Some flights will be lightly loaded and others heavily loaded.

Each MSP offers the airline one or more service levels. Not every MSP will offer the same service level.

Each network QoS or IFC QoE measurement must be scored. The Seamless Air Alliance Tech Forum and Airline Forum have spent considerable time defined a scoring table for each measurement. Each scoring table is formatted with five levels of service:

Score	Service Level
+2	Great Home-Like
+1	Good
0	OK Acceptable
-1	Poor
-2	Bad Unusable

As much as possible, a "home-like" experience anchors the scoring for +2, a great experience. However, each measurement has unique attributes that require some fine tuning.

> "I'm fully aware of physics. I'm aware that geostationary networks have higher latency. No one can do anything about that, but the passenger doesn't care.
> Should the score be better?"
>
> **Floris Reimbold, Lufthansa**

IFC QoE is influenced by latency.

A browsing experience over GEO typically scores up to 0, OK, no matter the data rate. A LEO network with achieved low latency has the potential for a +2 great browsing experience. While it can be shown that a GEO network is operating perfectly, the passenger browsing experience may be muted.

Any MSP can offer scalable forward channel capacity to drive streaming experience to +2 for specific resolutions.
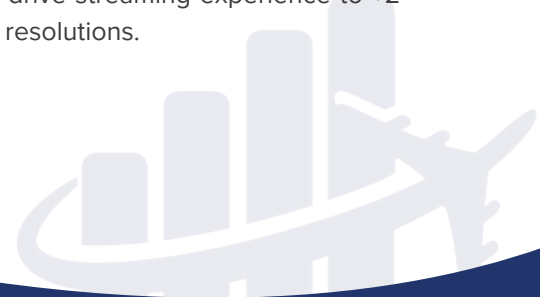
Hybrid networks operate with satellites in multiple orbits, generally GEO bundled with LEO/MEO. IFC service using a hybrid IFC network will behave differently depending on the selected satellites in service. Network QoS must be customized based on the blended service offering. IFC QoE operates without regard, reflecting the service as delivered.

The airline is far more concerned about avoiding poor or bad IFC experiences than driving good or great. In many cases, OK is perfectly fine. Reliable and predictable service levels can set expectations with passengers and improve their satisfaction. The airline must have confidence for delivering the same passenger experience throughout the contract lifetime.

An airline and MSP can set the expected score for each measurement, whether it be 0, +1, +2, or even -1.

For IFC QoE, particularly around streaming, the airline and MSP should agree on expected resolution for uninterrupted playback.

Some airlines may expect 480p streaming, others perhaps 720p or higher, while others satisfied with 360p.
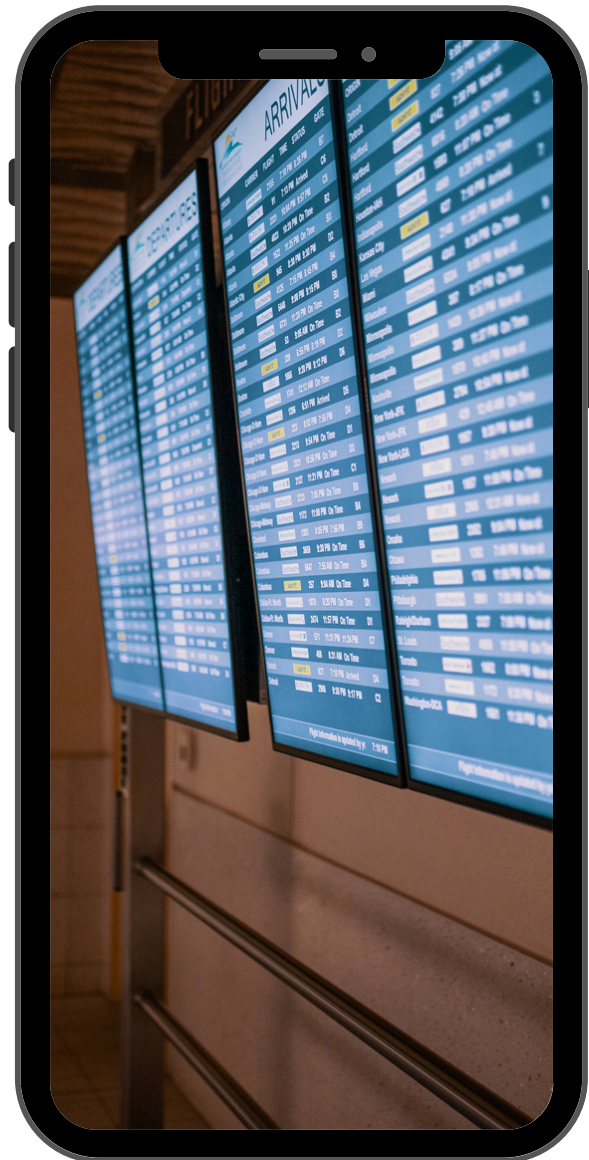
12. NETWORK OUTAGES

IFC network outages come in two flavors: planned and unplanned.

Planned outages include for example, flight routes that step outside of IFC network coverage or scheduled maintenance. The airline and MSP can predict when planned outages will be encountered and provide for passenger awareness to set expectations and minimize passenger frustration. A key attribute of planned outages is knowing when to expect service recovery.

Unplanned outages are not predictable by their very nature. It may be impossible to predict when service will recover from an unplanned outage. These factors amplify passenger frustration.

IFC QoE measurements reflect the passenger experience. IFC QoE will be unacceptable during an outage, planned or unplanned. In the end, the passenger doesn't really care why the service is not available, it's just not available.

In all cases, letting the passenger know that the service is not available can stave off their frustration trying repeatedly to fix it. Reliably letting passengers know when to expect IFC service to be restored offers the best experience in a trying situation.

An SLA can allow for post-flight exclusions to account for planned outages when considering remedy.
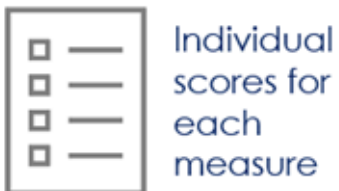
13. COMBINING IFC QOE MEASUREMENTS

The Seamless Air Alliance has established a series of essential Quality of Experience metrics to monitor, which can be combined in a weighted manner to produce a session satisfaction score retaining the use of a scale from -2 to +2.

1. Network Performance

Individual scores for each measure

2. Browsing Performance

Individual scores for each measure
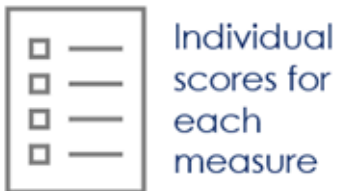
3. Streaming Performance

Individual scores for each measure

SESSION SATISFACTION SCORE

14. SEAMLESS AIR ALLIANCE TEST LAB

> *"Testing in a lab environment is just not the same as in flight. It just never will be the same no matter how hard we try."*
>
> *Anna Sieber, JetBlue*

The Seamless Air Alliance working with GlobalReach have established an IFC test laboratory. The network is available to each test site using a Seamless Air Alliance configured wireless access point (WAP). Each WAP securely tunnels all traffic to the GlobalReach Enterprise located in Ireland. GlobalReach then applies network controls to simulate onboard networks that represent LEO and GEO satellite networks yielding IFC QoE levels from bad to great within the boundaries of latency effects. Test sites can also utilize their own PoP, a mobile PoP, or even a local satellite PoP to complement the GlobalReach-managed networks.

Each test site can then conduct repeatable tests with a small number of clients to evaluate application-specific QoE measurements across the spectrum of expected performance levels. The Seamless test laboratory has been a critical element for establishing measurements, scoring tables and satisfaction-level combining algorithms.

Validation testing from fly-along test campaigns has been used to show a correlation in performance levels.

The Seamless Lab lets any alliance member test with experience level using their own device from their home location.

15. CONCLUSION

Airlines need SLAs as a part of any IFC MSP contract. Escalating remedy ensures that the airline can be assured of service levels or otherwise an exit strategy.

Network QoS is sufficient to manage the IFC network but does not guarantee IFC QoE.

IFC QoE application-specific measurement and satisfaction levels should be a part of an IFC SLA to guarantee the passenger experience.

Seamless Air Alliance Tech Forum and Airline Forum have developed tools, test facilities, measurement methods, scoring tables and combining algorithms to define IFC QoE.