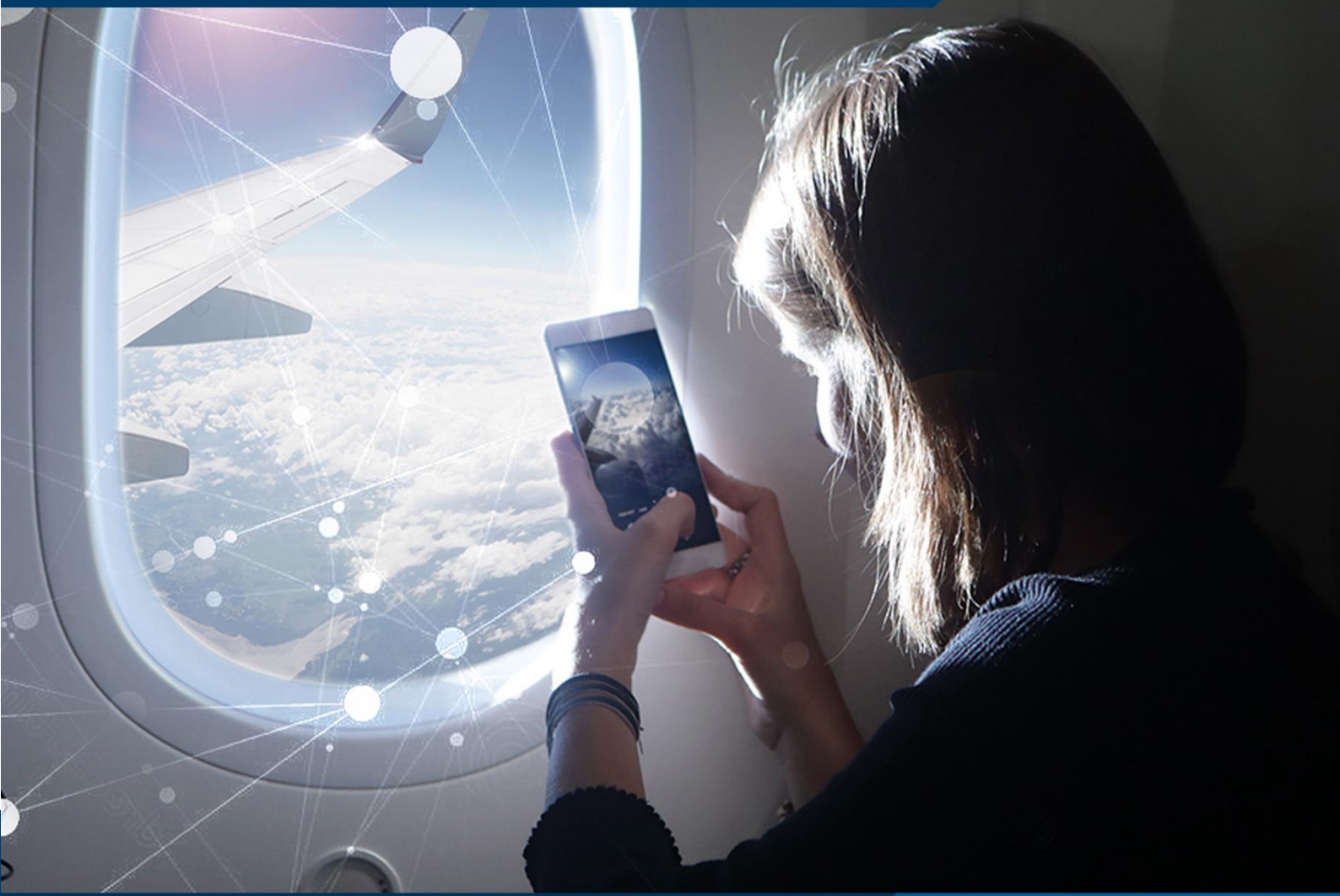
In-Flight Wi-Fi Connectivity

Improving Passenger Experience, Engagement and Uptake

Source:	WBA
Author(s):	WBA In-Flight Connectivity
Issue date:	October 2022
Version:	1.0.0
Document status:	Final



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WBA undertakes programs and activities to address business and technical issues, as well as opportunities, for member companies. WBA work areas include standards development, industry guidelines, trials, certification and advocacy. Its key programs include NextGen Wi-Fi, OpenRoaming, 5G, IoT, Testing & Interoperability and Policy & Regulatory Affairs, with member-led Work Groups dedicated to resolving standards and technical issues to promote end-to-end services and accelerate business opportunities.

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Executive Summary

The availability of Wi-Fi in aircraft isn't new. For more than a decade, airlines have been offering internet connectivity to passengers as a premium service. With the advent of faster, higher bandwidth satellite connections and alternative cellular-based air-to-ground networks, the cost of providing that service reduces the barrier for passengers to connect and use. These factors also allow airlines to differentiate their service from others either by price and/ or available speed, thus enhancing the passenger experience over their competitors.

In traditional airline scenarios, access to entertainment has been provided in seat back screens. Following the introduction of Wi-Fi in aircraft, airlines have been able to offer personal device entertainment as a replacement for, or in addition to the seat back screens, and have therefore had a touchpoint with users as they join the network via a browser or app to gain access to entertainment. The same portal has allowed passengers to access the internet after appropriate payment.

With the evolution of Wi-Fi networks towards Passpoint® on the ground, users with a valid subscription installed on their device(s) can automatically connect to Wi-Fi networks without requiring any further interaction. This provides convenience for the user, since they will be connected to the network without needing to do anything and allows them to remain connected at all times. However, it presents a challenge to airlines wishing to maintain the touchpoint with their passengers through in-flight portals.

The COVID-19 pandemic had a devastating impact on the airline industry, but as global travel picks up again, so do opportunities to improve the passenger experience. Airlines will be keen for people to fly again, and any enhancements to passenger experience and value-added services that improve brand awareness and connectivity will make passengers more comfortable throughout their journey by giving them access to stay connected with more ground-based services.

This paper aims to help industry stakeholders, and particularly the airlines, to understand how to develop a holistic connectivity experience for the passenger allowing users easy connection to the in-flight service and outside internet, while maintaining access to the airline portal for flight information, entertainment or additional purchases.

User experience and identity management have also been thought out and covered in detail so that the handover between the cabin Wi-Fi and the internet - often only accessible above 10,000ft - can happen smoothly and allow opportunities for roaming monetization.

Finally, this work designs a paradigm shift for the aviation sector, in which the passenger roaming experience is not restricted to the aircraft, as federated services such as WBA OpenRoaming™ allow them to connect at additional locations throughout their journey to the airport, and finally on board the aircraft. A gate-to-gate, and local roaming, experience can open new loyalty opportunities for the airline to stay much closer to the passenger.

Defined Terms

Airline Portal: a browser-based portal available on the aircraft, accessible from devices before and after internet access is available, which allows the airline to deliver services such as flight information, in-flight entertainment, and to buy access to the internet and/ or other services.

ANP: *Access Network Provider:* a provider that owns one or more roaming enabled Wi-Fi networks. The network may be present in the aircraft, an airport, a residential network, university, etc.

CAPPORT: Also known as Captive Portal API, refers to a method developed by the IETF for making a web address consistently available to a user that connects to a Wi-Fi network. This address or link can be displayed in the end-passenger device, persistently, allowing users to return to the original captive portal URL.

IdP: *Identity Provider*, a service provider with which a user or mobile device has a subscription and associated credentials. The IdP typically enrolls users and/ or device, creates network access credentials, bills the end user, and authenticates network access requests.

IFE: *In-Flight Entertainment*: the content and flight information delivered within the aircraft network to the passenger – often this includes TV, movies, podcasts, songs, games, and purchasing options such as special meals or amenities.

In-Flight Wi-Fi: the direct and closed connectivity existing between an aircraft and the end-passengers' device.

Internet connectivity: in this case, the availability of outside internet connection for a passenger's device, providing access to applications such as chat, browsing, streaming, enterprise networks, etc., served from the internet rather than from onboard systems.

Onboarding: see provisioning.

OpenRoaming™: a WBA roaming federation service enabling an automatic and secure Wi-Fi experience globally.

Passpoint®: also known as Hotspot 2.0, the Wi-Fi Alliance's Wi-Fi CERTIFIED Passpoint technology that facilitates secure, automatic connection to Wi-Fi networks, for devices provisioned with a suitable subscription profile. Passpoint profiles can be used for **OpenRoaming**, as a federated code (RCOI) is added and can be used to scale up access worldwide to multiple networks at once.

PLMN ID: *Public Land Mobile Network Identifier*, the combination a network and country code which can be broadcast on a Wi-Fi network indicating that suitably configured cellular devices can connect to Wi-Fi networks with a SIM-based authentication.

Provisioning: the process of downloading and installing a Passpoint profile onto a user's device.

RCOI: *Roaming Consortium Organization Identifier*, a parameter broadcast on Wi-Fi networks indicating that a roaming service is available. Devices having a subscription containing a matching value may attempt to authenticate with the network. OpenRoaming uses the RCOI Management Object to allow the massification of roaming between identity and network providers.

ROI: Return on investment

Subscription: a credential and network configuration used by a device to connect to a Wi-Fi network.

TCO: Total cost of ownership

WBAID: *WBA Unique Organization Identifier*, *a unique identifier allocated by the WBA or authorized agent to access network providers, whether the ANP is a WBA member or not*. Used in RADIUS messages to primarily to identify the legal entity behind a given network.

WRIX: *Wireless Roaming Intermediary eXchange*, the WBA framework for implementing Wi-Fi roaming, composed of documents such as WRIX-n for Network, WRIX-d&f for Data and Financial clearing, WRIX-i for interconnection, WRIX-L for Location and a set of roaming templates and support documentation.

1. Introduction

In the context of this paper, connectivity is used in the form of outside internet access. The onboard Wi-Fi service facilitates device connections to the aircraft, providing access to onboard services including in-flight entertainment (IFE) and internet access. Before any device can get access to the internet on an aircraft, it must first successfully 'associate' with the Wi-Fi service. There is currently no standard, consistent method for devices to get associated to the in-flight systems, so the user gets a different journey for each flight they take – and in some cases for each flight segment within the same airline.

Some of the existing scenarios include, but not limited to:

- Gate-to-gate service: Wi-Fi connectivity which gives passengers access to the airline's Wi-Fi network and internet connectivity as soon as they step on board the aircraft
- In-flight Wi-Fi enabled, but internet connectivity not enabled until cruising above 10,000ft
- In-flight Wi-Fi service and internet connectivity not enabled until cruising above 10,000ft

Nevertheless, the success of In-flight connectivity is predicated on the ability for ubiquitous adoption. Therefore, this includes the experience to connect and use, as much as the service itself. For this to make the transition from niche to mainstream, it is important for the connections from the late majority and laggards of society to be able to access easily and use, and not just the tech savvy innovators and early adopters who have been using so far.

Connectivity on the ground is so widespread because it requires no thought; only when this is facilitated in the cabin will up-take even attempt to be comparable.

When it comes to the network technology deployed in aircraft, it is acknowledged that Wi-Fi 6 could permit more users to connect to the network than with Wi-Fi 5 with the same number of access points, but selection and definition of network technology is out of scope for this document.

2. Stakeholders

The following are stakeholders (what are they looking for and what do they offer) in the connectivity services:

Airlines

- Make the commitment to pay for, install and carry the hardware on each flight
- Want a return on that investment
- Want to differentiate vs. competition, or offer a hygiene product
- Drive positive passenger experience / brand engagement with in-flight service/ ancillary revenue including IFE

Passengers

- Want to be connected
- Have an expectation of experience once they are connected and how to connect
- Want a simple onboarding process and stay connected during the journey

Identity providers

- Mobile network operators & multiple service operators
  - Want to offer value to their subscribers in a highly competitive environment when travelling to their destination as well as when they arrive
  - Have the unique identifier, and ability to facilitate access through over-the-air updates
  - Serve a huge number of customers via SIM with Wi-Fi enabled devices using their SIM for authentication
- Loyalty programs
  - A key revenue driver for airlines & other partner programs
  - Supports the wider airline revenue streams, and supporting their highest value customers is a big strategic priority for them
  - This is an additional way to provide value and a reason to fly with a particular airline
- Over-the-Top (OTT) providers
  - Increasingly prevalent within the market
  - Continued to engage with the base ensures reduced churn and increased loyalty

- Offering connectivity enables engagement with their service in an additional location

Infrastructure providers

- Network providers (WISPs), backhaul providers (satellite, Air-to-Ground (ATG)), and hardware & software vendors
- Need connection experiences to be simple and easy to increase take-up
- Service continuity for passengers
- Increased network utilization supports costs and drives future investment
- Demonstrate value to airline customers supporting goals and objectives
- More users connected means more data transfer and in turn increased revenue opportunity

Ecosystem brokers, hub providers etc.

- There are several companies providing hub services that facilitate roaming by connecting networks to each other and to other identity providers. This group act as enablers between other stakeholders helping them to maximize ROI.

3. Use Cases

Use cases, as used in agile software development, help to describe the wishes and the intentions of users in order to specify the features of solutions.

In this document, we describe use cases from the point of view of stakeholders.

3.1. As a passenger on an aircraft

1. I would like to have gate-to-gate connectivity to the Wi-Fi network of the plane

   So that I can access the on-board content immediately and continuously until the end of the journey.

2. I would like to be offered internet connectivity during the flight

   So that I can access the data and the content I need.

3. I would like to have control over my internet connection – connecting when I want (with payment if required), knowing I'm connected and being able to disconnect when I want.
   So that I avoid unexpected charges.
4. I would like to have the above service independently of the type of device I use, of the service provider, whose customer I am, and of the airline I am flying with
   So that the experience remains simple and consistent, and I do not have to care about these points when I am travelling.

3.2. As an MNO mobile subscriber

1. I would like to access the internet on board of my flight with my smartphone or tablet (with a SIM card)
   So that I don't have to remember my credentials or install an app to enable the access
2. I would like to pay for the service (if its usage is not included in my subscription) through my MNO bill
   So that I don't have to look for my credit card and enter details during the flight
3. I would like to receive clear cost information before I log on, and throughout my flight
   So that I don't have to fear bill shock over using the in-flight internet

3.3. As a customer of non-MNO providers

1. I would like to access the internet on board with my device via a subscription service
   So that I don't have to remember my credentials or install an app to enable the access
2. I would like to pay for the service (if its usage is not included in my subscription) with a retail partner
   So that I don't have to look for my credit card and enter details during the flight
3. I would like to receive clear cost information before I log on, and throughout my flight
   So that I don't have to fear bill shock over using the in-flight internet

3.4. As an airline

1. I want every passenger to have access to the airline portal, accessible through the on-board Wi-Fi network
   So that every passenger can see my airline branding and available services.

2. I want to offer different services and content to my passenger through the on-board portal
   So that the passenger engagement and loyalty are increased, leading to better value perception, and retention through delivery of entertainment and information services onboard.
3. I want to offer internet connectivity to the passenger as an additional service
   So that the passenger, whether business or leisure, can continue with their online experiences in the air as they do on the ground. This will increase passenger brand loyalty, increase my Net Promoter Score (NPS), and provide an additional revenue stream.

3.5. As a connectivity provider

While passengers and airlines can be considered as the main stakeholders in in-flight connectivity there are other stakeholders which are enablers for the service and are interested to develop an own business in this field.

As a **Satellite or Air-to-Ground provider**

1. I want to support multiple partnerships with identity providers, content providers, etc., *to offer any of their services to customers on a given flight.*
2. I want to be the network provider of multiple airlines asking for internet connectivity.
   So that I have return of investment and growing revenues.
3. I want to support a seamless roaming experience for passengers with a high-speed Wi-Fi connection that provides a high Quality of Experience (QoE)

   I want to provide a highly reliable and secure Internet connection to both the onboard airplane subsystems and the passenger's Wi-Fi connected devices onboard the aircraft.
   So that I can support and/or enable airlines services offered for the aircraft, to the cabin crew and to passengers.

3.6. As an internet service provider

As a **non-MNO identity provider**

1. I want my customers to access the internet in the in-flight footprint offered by different airlines

So that I can offer more value to my subscriber and generate retail revenues at the same time.

2. I want to use industry standard roaming processes

   So that I can use established commercial processes.

3. I want to receive usage data from the airplane in the same way as I do for terrestrial roaming traffic

   So that I can invoice my subscribers based on their consumption.

4. I want to clearly distinguish between in-flight roaming and terrestrial roaming traffic

   So that I can create different propositions and to offer my customers a seamless experience if I choose so.

As an **MNO commercial / portfolio manager**

1. I would like to be able to offer in-flight internet to my customer as a cellular roaming-like experience

   So that I can manage the monetization of in-flight internet, give my customer a clear communication about the cost, and protect them from bill shock.

2. I would like to offer a selection of retail products

   So that we can always offer the best proposition to our subscribers.

3. I would like to implement roaming easily and in a standardized way on the airplanes of all airlines

   So that I can avoid implementation costs and delays.

4. I want to receive usage data from the airplane in the same way as I do for terrestrial roaming traffic

   So that I can invoice my subscribers based on their consumption.

5. I would like the option of implementing home routing so that I can control the user policy

   So that I can provide my customer the same services as if they were on the ground e.g., content filtering, local content etc.

As a **wholesale business owner/broker** of flying footprints,

1. I want to market my asset, the in-flight internet footprint, to Identity Providers

   So that I can generate roaming revenues on top of my retail revenues (if any)

2. I would like that my customers can implement easily and in a standardized way roaming on the airplanes of all airlines

   So that implementation costs and delay are avoided.

3.7. As an avionics vendor

1. I want to offer network elements (wireless access points and possibly switching and/or routing elements) that support each of the use cases for passenger access (captive portal, Passpoint, etc.)
2. Through proper selection of device hardware, I want to offer network elements that deliver high performance under the load of hundreds of concurrent connections and high bandwidth consumption (e.g. streaming of Ultra High-Definition (UHD) IFE content).
3. I want the operational performance of my network elements to be easily monitored and reported on by the network operator.
4. I want my network elements to be cloud-managed, but functional autonomously so they can centrally managed, but operate correctly without Internet connectivity.
5. I want my network elements to have a low TCO profile by offering easy-to-use interfaces that network operators can incorporate into their operations support system.
6. I want my network elements to have a strong ROI for network owners by selecting the most contemporary hardware and being software definable/upgradable, extending the useful life of the deployed asset.
7. I want to be in a position to offer network elements that have already been certified by regulatory bodies, removing that burden from network owners/operators and facilitating faster market availability.
8. I want to ensure that in-life service modifications can be made remotely without requiring re-certification.

4. Challenges

The historical challenge of providing in-flight internet access has been cost and experience: satellite bandwidth has traditionally been expensive, sporadic, and offered slower speeds than passengers were used to on the ground.

These factors resulted in less than optimal and confusing propositions being positioned on the aircraft for passengers to choose from and select. Coming from a world on the ground where connectivity offerings are fast and unlimited, the concept of what a megabyte is, and how many are consumed how fast is typically lost on the standard passenger.

Although the increase in satellite numbers offering connectivity and different communication bands has led to the addition of capacity and speed to the satellite network, there are still challenges to overcome in order to develop and offer solutions for the use cases described earlier.

In the following overview, some of the remaining challenges are listed and discussed.

Chargeable access

- This continues to remain the primary method of connection on offer to the passenger
- Airlines pay for the installation of the equipment, and there is the weight that needs to be carried
- This is also a source of ancillary revenue for the airline that they have come to rely on, especially now in a post-COVID world where revenue is so important
- Price sensitivity from passengers continues to deem this the most important issue, and a barrier to use in-flight

In-flight service availability

- This is increasingly becoming less of a factor from a coverage perspective as more ATG and additional satellite services become available
- However, there are some regulatory challenges that still mean that there may not be global coverage for geo-political reasons

Internet availability

- With the introduction of gate-to-gate service, this is becoming less relevant

- However, this is not the norm, and there is the period from leaving the gate to 10,000 feet that may not have any connectivity options
- Airport taxiways are often not prioritized for high-speed cellular coverage as these are not high-density sites for their subscribers

Continuous connectivity

- Technologies are improving, and the disruptions that may have been more common in older systems (e.g. switching between satellite beams) as technology improves
- With the newer systems, and the improvement in OTT applications for even things like streaming, these beam switches are unlikely to even be noticed

Connection experience

- Passengers on an aircraft will be used to being able to access the internet automatically
- Needing to connect to the right SSID, navigate to the correct landing page, before even finding the payment page, registering, and paying is a big barrier
- In an online journey, each incremental step usually leads to a 50% drop out
- There also is the requirement for some level of knowledge to run through this connection experience
- Once internet access is established, if users connect to VPN services, access to local onboard services is prevented, and users must disconnect from VPNs to regain access to these

Awareness:

- This is improving, but there are still those that do not know that connectivity is possible on aircraft
- Greater engagement with partners will change this as it becomes more mainstream
- This also varies from region to region
-
- Air travel has been considered the last bastion of connectivity silence, and some continue to enjoy “switching off”
- As the performance improves, this will dissipate

Aircraft Hardware:

- Whilst there is a trend for new, more efficient aircraft to be introduced into fleets with the most up to date Wi-Fi technology onboard, there is a large legacy of aircraft with older access points onboard
- These offer different levels of experience options for the airlines, and make uniformity of the experience challenging
- Whilst these are being increasingly retired, it will lead to an inconsistent experience for passengers in the cabin

Passenger devices:

- There will be different aged devices with different operating systems and levels of capability, and therefore experience offered
- To market a connectivity proposition, it is important that the majority of passengers onboard should be able to access and use it in the intended way, and with the desired passenger experience

5. Solutions

In addition to the WBA In-Flight Connectivity team's thoughts and recommendations below, it is important to accept that no single solution can be applied universally. Airlines must work with their infrastructure providers to agree which access method or methods should be adopted to support their specific use cases and flight path requirements, as well as to simplify the onboarding process while retaining passenger touch points and simple access to internet services.

Traditional captive portal methods require users to a) know the SSID and b) know the portal URL to enter into a browser in order to access the service. The latter manual step is a natural barrier but should remain as a solution for passengers with no other method of connection.

Implementing Passpoint service on the aircraft network opens new opportunities for automatic connectivity and gives access to a greater variety of roaming opportunities.

- Passpoint subscriptions can be provided by airlines – as a "home" default network, or by cellular or other providers.

- Device configuration profiles can be pre-loaded by carriers or can be installed by mobile applications, user downloads from a web service or via on-network Online Sign Up (OSU) service.
- Passpoint is a pre-requisite to supporting the WBA's OpenRoaming federation which can be enabled by adding the appropriate Roaming Consortium Organization Identifiers (RCOIs) to the network.

Ideally, the network should not signal services which are not available (e.g. via RCOI/ NAI realms) to prevent user frustration when devices do not attach (despite appearing in the device's Wi-Fi SSID list) due to there being no internet connection. It may also be necessary to provide a local authentication mechanism to allow device attachment to a secure network when there is no ground connection for authentication.

The onboarding experience can be further enhanced with the implementation of the CAPPORT API on the network. This allows the network to signal to supported devices where the captive portal can be found, irrespective of the network association mechanism (i.e., open network or Passpoint).

The device then notifies the user that they can tap to access the captive portal service – both for sign-in and after authentication to return to the portal page. This service is activated on the network using Dynamic Host Configuration Protocol (DHCP) – so is simple to configure and applies to all users on the network, whether there is a subscription installed on the device or not, and crucially whether it was provided by the airline *or* a roaming provider.

This is important to airlines because their touchpoint with passengers is maintained due to there is a persistent notification on the device to guide users back to the airline portal.

Examples of device behavior on a CAPPORT-enabled network can be found in **Appendix A.**

In addition to passenger onboarding, there is a further benefit of using Passpoint networks on aircraft: access for crew members. Having a locally authenticated Passpoint network on the aircraft would allow crew members with profiles installed by the airline – and different from passenger profiles – to access the in-flight systems automatically, on a separate WLAN from passengers.

This could give secure access to a crew portal and/ or application offering content such as seating plans, logistics, flight plans etc. Using a separate WLAN also gives airlines the opportunity to give crew access to the internet via separate authentication methods from those used by passengers.

5.1. User/Device Onboarding

Before a user can even access services – whether for on-aircraft use (e.g., IFE) or full internet access – they must connect to the Wi-Fi network. There are two main options for this, which can co-exist:

5.1.1. Manual association

Where there is no Passpoint support or, a user has no subscriptions installed, they can manually select an open SSID when inside the aircraft, which can give access to be free or paid internet service according to the airline business model. As described above, the additional use of CAPPORT can guide users to the portal on supported devices without having to know the URL of the portal.

Passenger User Journey – Open Network for manual association

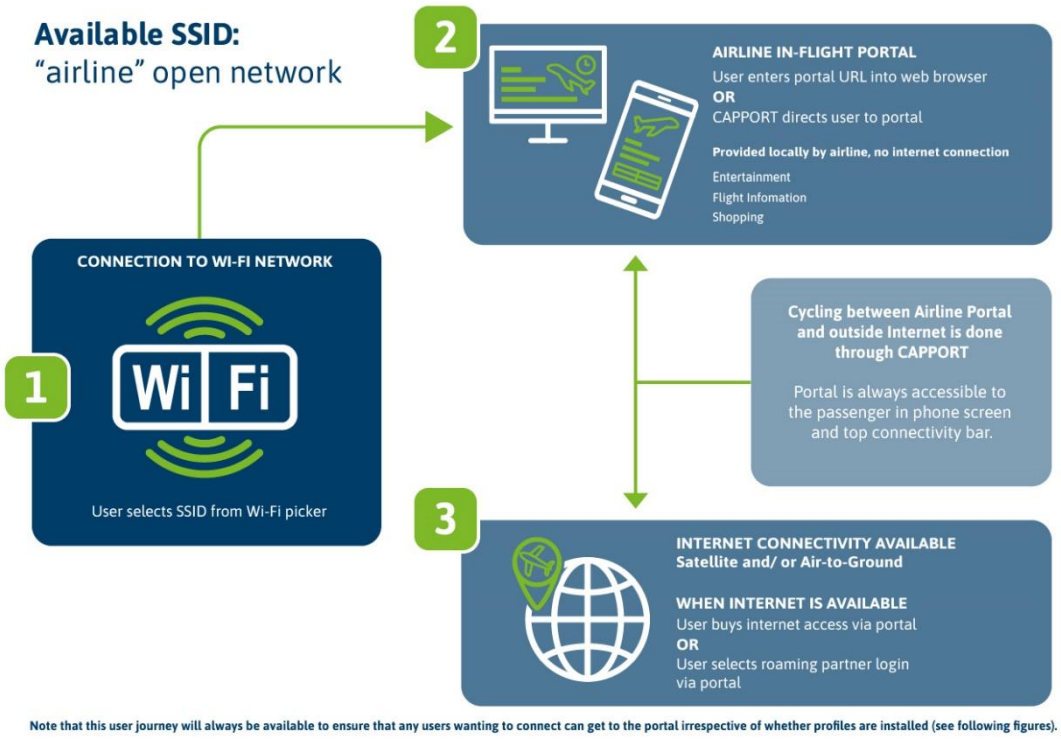

Figure 1 – Wi-Fi onboarding for legacy open network*

* Assumption: Users do not have pre-purchased internet access

The services offered in the airline portal may include content such as

- Flight route maps and data
- Weather
- Destination information
- Internet purchase
- Roaming/ Enterprise access
- Food and beverage menus and/ or ordering
- Duty-free shopping
- Third-party provider content

The steps and options presented above in Figure 1 represent traditional options that are used for onboarding passengers without Passpoint subscriptions to an aircraft Wi-Fi network. Note that not all options may be available on all aircraft.

It is also worth noting that there are many places in this scenario where users may abandon the connection process, e.g., not knowing the SSID, not being able to get to the portal, and not wanting to pay for internet access once they've navigated to the right place on the portal. These exit points are not influenced by the type of device being used (smartphone, tablet, laptop etc).

5.1.2. Automatic association

By leveraging Passpoint in the aircraft, the association to the network can be automated if the user's device is configured with a Passpoint subscription profile offered by the airline or another identity provider. This automatic association gives a more cellular-like experience with transparent connection to the network.

If an airline provides its own Passpoint subscription, it can be configured to match the domain name in the network's Passpoint beacons which will ensure their profile is matched before any roaming subscription that may also be installed on the device.

The authentication for this subscription could be processed locally on the aircraft, allowing association when there is no internet connection e.g., below 10,000 feet. Airline profiles could be downloaded by passengers at the time of ticket purchase, or via the airline's loyalty application.

Even if the user has both airline and other roaming subscriptions installed on their device, the user will always be able to select an alternative from their device's Wi-Fi picker should they wish to change to a different provider.

Passenger User Journey – Local & Roaming Passpoint Networks for automatic association

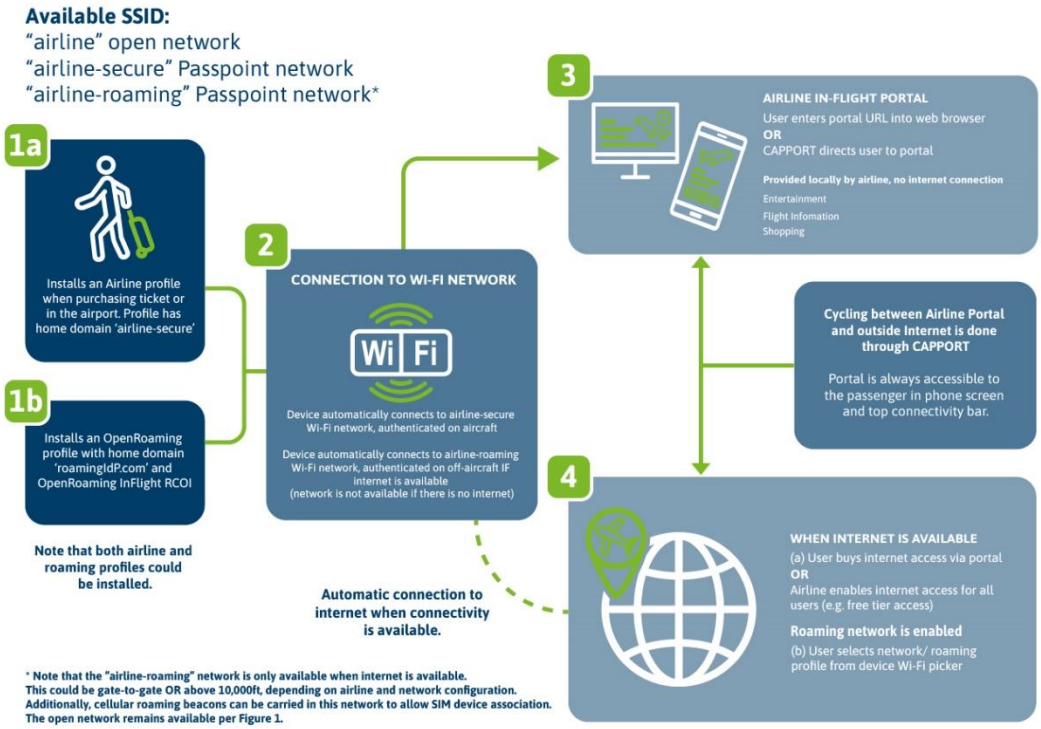

Figure 2 – Wi-Fi onboarding for Passpoint networks*

The services offered in the airline portal are the same as those offered on the Open network – see Figure 1 above.

Note that if there is no internet connection, care should be taken not to advertise roaming indicators such as RCOIs, NAI realms or PLMN IDs that could cause the device to attempt a connection that would never be successful due to the missing route to an authenticator. PLMN IDs would be carried on the "airline-roaming" networking shown in Figure 2 when that network is enabled. Further details about the cellular experience can be found in an earlier WBA's In-Flight Connectivity whitepaper.

For those users taking advantage of roaming subscriptions to access the internet but also consuming on-aircraft services such as movies etc., it is important to ensure that they are only billed for traffic that originates on the ground and not for content served by the aircraft.

* Assumption: Users do not have pre-purchased internet access

Further research is required into the exact final implementation to ensure that user experience is not adversely affected when users switch between airline and roaming networks on the aircraft. Given that 'home' and 'roaming' networks are carried on separate SSIDs, each will typically have a different MAC address as far as the networks are concerned and therefore the device will present with different IP addresses.

CAPPORT, if enabled, will still give access to the portal, but it is possible that if a user starts watching a movie on 'airline-secure', switches to 'airline-roaming' and goes back to the movie, that the portal will not remember this device and the movie may restart. Depending on IFE implementation, this could be mitigated using cookies.

5.1.3. Crew access

Similar to passenger Passpoint access, a separate crew Passpoint network can be configured with profiles added to their devices to allow them to connect automatically to the aircraft network for access operational systems.

Passpoint Network for Crew Use

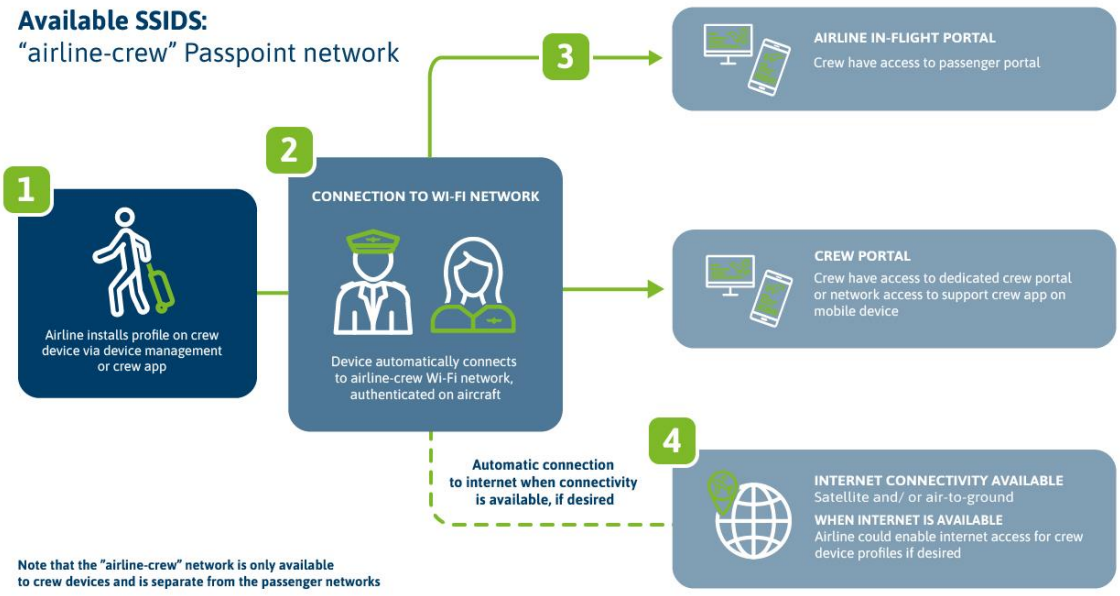

Figure 3 – Wi-Fi onboarding for crew Passpoint networks

5.2. Roaming

As with cellular roaming, where a user arrives in coverage of a visited cellular network and their device automatically connects, the same experience can be implemented for Wi-Fi using

Passpoint technology. Additionally, other forms of roaming that require connection clients can be used should the user have access to such services.

As noted above, it is important that roaming capabilities should not be advertised on the network until the service is available to ensure the best user experience. This includes broadcast of RCOIs, NAI realms and PLMN IDs that could be used for device association.

Industry Onboarding Evolution

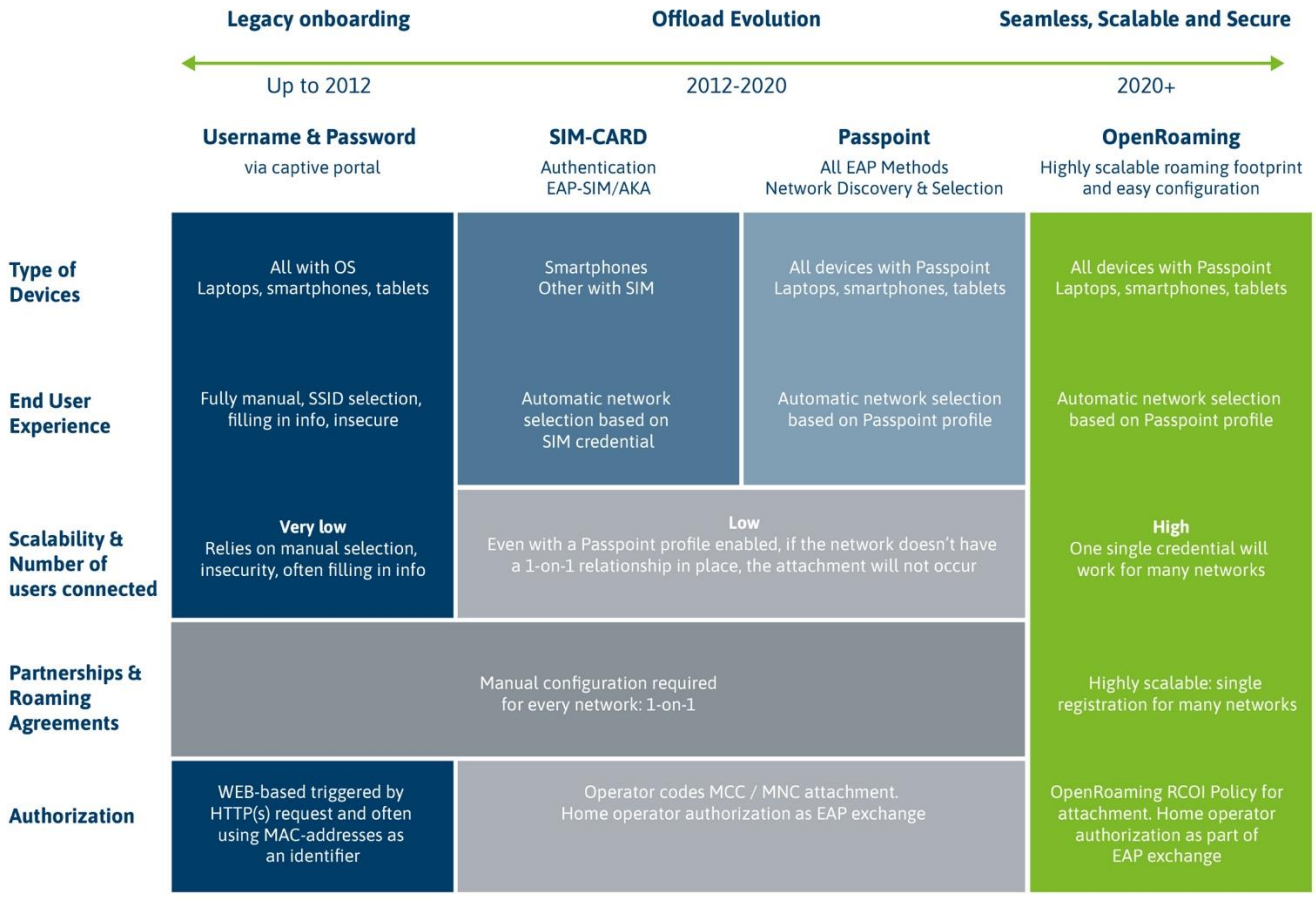

Figure 4 – Industry Onboarding Evolution

Assuming there is an active internet connection, there are multiple ways that roaming can be implemented, depending on who is providing the user identity:

5.2.1. Cellular providers

Cellular operators wishing to offer in-flight roaming services can do so either via bilateral roaming agreements or via the WBA's settled OpenRoaming federated roaming scheme. This

allows users to continue to have a cellular-like connection experience via the in-flight Wi-Fi service.

Note that if the policy applied by the cellular provider implements home routing, where the user appears to be connected to the provider's network via network tunnels, access to onboard services will be prevented.

5.2.2. Non-cellular identity providers

For non-cellular identity providers, connections may be implemented either using connection software supplied by the provider or by installing subscriptions on user devices to facilitate automated connections. Using the Passpoint route, providers can again leverage either bilateral agreements or OpenRoaming to provide roaming service.

5.2.3. WBA OpenRoaming

The OpenRoaming™ federation allows users to connect to multiple networks throughout their journey. In addition to any OpenRoaming subscription the user has on their device(s), there is a prime opportunity for airlines themselves to become identity providers and to distribute their own subscription profiles to their passengers.

By leveraging a domain in the subscription that matches that in aircraft, devices will auto-associate with aircraft network in preference to any roaming profile(s). Additionally, the subscriptions can include one or more OpenRoaming RCOIs that would allow auto-connection to other networks in airports, hotels, and any other key locations along the passenger journey.

Using a static identifier in a Passpoint profile for the user allows airlines have more knowledge of where their users are connecting and to control the user experience better. There is an additional benefit that the negative impacts of MAC address randomization are mitigated, thus reducing the number of times users may be required to sign-in to networks.

By broadcasting OpenRoaming RCOIs in aircraft, there is further benefit to network providers since the network can be configured once to support many users, rather than having to configure each network for multiple cellular providers.

The airline's overheads are therefore reduced by having user device configuration driving connections rather than network configurations – configure once, connect many.

An additional advantage of using OpenRoaming is that by leveraging multiple RCOIs in the network and network configurations, it is possible for a user to be connected throughout their journey, as shown in the following examples:

RCOI TYPE	BENEFITS
Settlement free	To allow free Wi-Fi roaming across all OpenRoaming networks (including airports, subway, other public venues, etc.)
Settled for aviation	To be used in the airplane when the internet service is available
Settled Silver for aviation	To be used for the premium customers – e.g. business class

Table 1 – OpenRoaming RCOI types and their purpose

As can be seen in Figure 2, once subscription profiles are installed on devices, automatic association to in-flight networks – and connection to the internet – can be achieved without users needing to access the portal if that is the desired behavior, though the airline may desire passengers to visit the portal for the touchpoint.

However, it remains important to highlight the need to keep the passenger informed about possible roaming prices to avoid bill shocks as much as possible. As previously discussed, implementing CAPPORT on the network will ensure users are able to get to the portal simply.

It is also important that airlines mark their Passpoint networks as 'chargeable' so that user devices are directed to consume data conservatively. Leveraging this feature means that devices will not automatically attempt automatic updates or background uploads/ downloads without the user directly initiating the process. This means that the available bandwidth is conserved so more users can benefit from it and helps lessen bill-shock by reducing background activity.

6. Conclusions

With new satellite capacity coming online, and more air-to-ground services becoming available, there are increasingly fewer impediments for airlines to offer internet connectivity.

However, there are significant and impactful changes that can be made to the user connectivity journey which will lead to an increased uptake and overall better experience.

Some, such as enabling secure Passpoint networks in aircraft and providing subscription profiles to devices can give users an even better, uninterrupted experience which can be enabled at the time tickets are purchased, as part of a loyalty program, and /or with the assistance of roaming partners. These benefits can increase usage of the in-flight networks, drive revenue through increased uptake of direct sales and roaming opportunities e.g., WBA OpenRoaming, and allow the provision of

standards-based services. Additionally, because the services are standards based, there is no need for aircraft to carry additional hardware such as picocells to provide cellular access; service can be provided over the Wi-Fi network as users are accustomed to on the ground.

Additionally, the implementation of CAPPORT on cabin networks will simplify the process for users to find the airline portal on the network and allow better access to in-cabin services e.g., flight maps, weather, and entertainment. However, the fact that the portal is now more accessible also leads users to engage more and to purchase additional services such internet access they may not have been aware of.

Further research is required into the exact final implementation of the solutions outlined in this document, and these will, in part, be addressed by WBA members in the subsequent phase of work, and particularly in the live trials and demonstrations.

REFERENCES

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- **Wireless Roaming Intermediary eXchange (WRIX) Framework**
  - Overview: https://wballiance.com/wi-fi-roaming-standard-wrix-umbrella-2022/
  - Full version for WBA Members only:
    https://extranet.wballiance.com/higherlogic/ws/groups/5d84bfbc-bbd6-437f-89ff-7034b52b226c?folder_id=899

- **WBA OpenRoaming**
  https://openroaming.org/

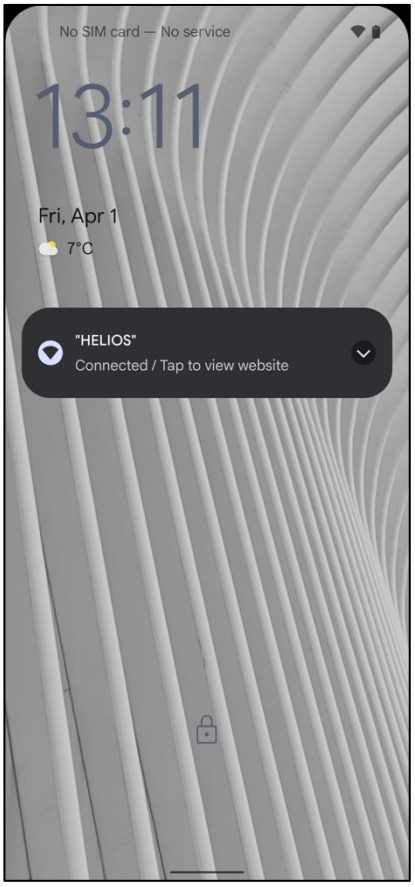
APPENDIX

Appendix A – CAPPORT User Experience

As described in section 4, the CAPPORT API can be used to aid user direction during and after the initial network connection. As can be seen in the following screenshots from an Android phone, users have quick access to the airline's onboard portal directly from their device's lock screen, whether they have completed sign-in or not. Similar access is available by swiping down from the top of the screen when the device is unlocked, giving multiple options for the user to return to the portal.

User has not signed in

User has signed in



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