November 2, 2017

To:

Shri. Syed Tausif Abbas

Advisor (Networks, Spectrum and Licensing),

Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg,
New Delhi- 110002

Subject: Comments on TRAI's consultation Paper on 'In Flight Connectivity (IFC)' dated 29th Sept. 2017.

Dear Sir,

Please find attached comments of SmartSky Networks, LLC (SmartSky) on the Consultation Paper No. 14-2017 dated 29/09/2017 on 'In Flight Connectivity (IFC)'

Thanking You,

Yours Sincerely,
For SmartSky Networks, LLC

Raghu Kulkarni
SmartSky Networks, LLC
Authorized Signatory

Encl.: As above.

SMARTSKY'S COMMENTS ON TRAI'S CONSULTATION PAPER ON "IN FLIGHT COMMUNICATION"

(Consultation Paper No. 14/2017 Dated 29th September 2017)

General Comments:

1. At the outset, we thank the Authority for issuing this consultation paper to discuss options for In-flight Communications in India.

2. There has been a paradigm shift in wireless telecommunication - from voice centric to data centric. Also, easy availability of smart phones at affordable prices has increased the demand for wireless broadband globally and India is no exception. India is not only catching up with the global trends but is leading the world in deployment of Information Communications Technologies (ICTs) through wireless broadband.

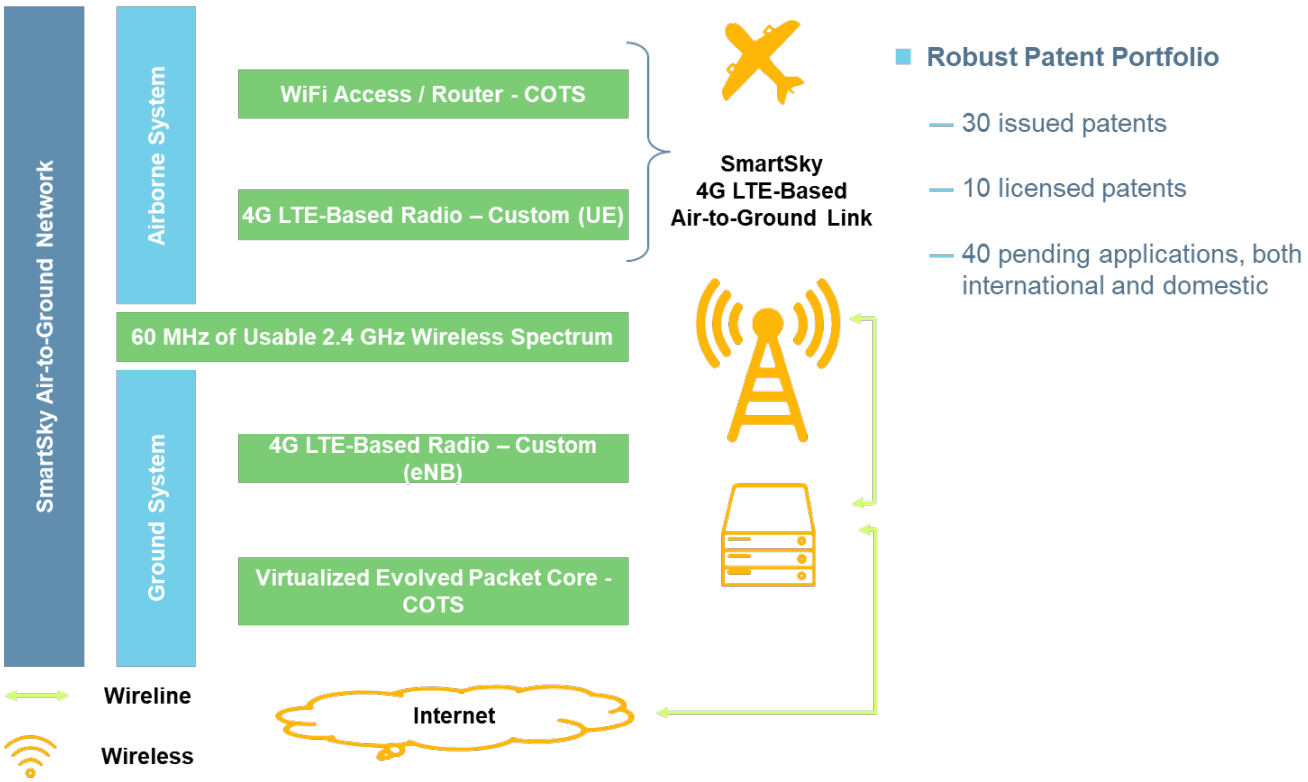
3. Commercial and business air passengers around the world increasingly expect and require fast, reliable broadband services while in flight. This demand is increasing, mainly driven by an increase in air passenger traffic, competition among airlines to provide best-in-class in-flight connectivity services, and by millions of passengers using smartphones, tablets and laptops. These travelers expect broadband connectivity that is similar to terrestrial wireless networks and Wi-Fi hotspots.

4. It is possible for the passengers to have telecom services in the Aircraft travelling at jet speeds and altitudes based on existing satellite-enabled connectivity or, while not specifically called out in this consultation, but highly significant to note, using Air-To-Ground (ATG) technologies.

5. LTE-based ATG with beamforming and sufficient spectrum has several compelling advantages to complement existing satellite based systems (when both systems are used on an aircraft) or to serve as a stand-alone service (when just an ATG system is deployed on an aircraft):
    - It offers the world's fastest in-flight broadband connectivity service with speeds comparable to 4G LTE on the ground.
    - It can provide higher throughput for both uploads and downloads. The ATG solution outperforms existing L band and Ku band satellite solutions in bit rates per aircraft, with the additional benefit of much simpler, lighter and less-expensive aircraft equipment, especially compared to the Ku band equipment.
    - The ATG solution outperforms existing Ka band satellite solutions in bit rates from the aircraft, and offers comparable or better bit rates to the aircraft (depending on satellite beam loading), with the additional benefit of much simpler, lighter and less-expensive aircraft equipment, especially compared to the Ka band equipment.

- Unlike satellites, the terrestrial cellular approach allows rolling out and expanding the network capacity exactly where it is needed by adapting the cell sizes or increasing the number of cells – flexibility that is not easily available from satellites.
- The time to install this solution on aircraft is one overnight stop compared to up to five full maintenance days for satellite-based systems.
- ATG LTE also can provide multimedia services to passengers should airlines decide to offer that option.
- ATG LTE is based on a fully standardized, future-proof terrestrial technology that has been adopted worldwide (but adapted for ATG use).

SMARTSKY'S PATENTED AIR-TO-GROUND SYSTEM…



- ATG features enable airlines and carriers to offer their passengers access to online services for work or leisure using their own devices with reliability and speeds previously only available on the ground. Rather than uploading recorded, often out-of-date content, the live connection allows the transfer of information at any time, opening the possibility of offering advanced services such as live TV on flights, or video-conferencing for business passengers. ATG LTE can be implemented as an independent cellular network or partnership with major network operators that provide retail services. This approach would facilitate seamless system management and consistent quality-of-service (QoS) delivery. SmartSky has successfully demonstrated an LTE-based ATG system solution in field trials to customers and involved regulatory bodies in the United States of America.
- ATG opens a new avenue for future innovations. It basically extends ground terrestrial capabilities to the airplane. To name a few:
    - It can enable real-time IoT data for different parts of the airplane that could be useful for airline manufacturers as well as ground control.
    - It enhances maintenance by offering real-time problem identification where maintenance crews can minimize the time for diagnosis and fixes.
    - It enables live video monitoring to help with security.

6. The ATG LTE solution offers cost-effective, optimized operations for airlines. The solution consists of an ATG RAN that requires some customization due to the unique use case of aviation resulting in the need to mitigate doppler effects, range extension, aircraft attitude, aircraft altitude, etc. However, standard LTE 3GPP interfaces to the core are supported. Any off-the-shelf LTE user equipment (UE) can work in the aircraft, interfacing through either Wi-Fi or a picocell that connects to the onboard router. ATG can be deployed and operated with less "downtime" for maintenance, and a relatively low equipment weight (as compared to satellite solutions) for efficient fuel consumption.

7. In addition to providing advanced passenger communications and entertainment services, airlines can upload and download important operational data via a broadband connection rather than through time consuming hard disk data transfers at ground stops. This reduces the time the aircraft needs to spend on the ground, improving its productivity.

8. The LTE ATG solution can be expanded further for cost-effective, higher-bandwidth services related to gate preparation, taxiing, takeoff, initial climb, approach, and landing – including ATG operation below 3,000 meters, if allowed by regulatory agencies and airlines.

9. Today's issues - Despite the satellite systems that are available today, there is still no cost-effective high bandwidth solution for in-flight broadband – especially for passenger infotainment with video on demand (VoD) and multimedia communications. Ku band and Ka band satellite solutions for creating the actual link between digital services and the airplane are efficient for long-haul flights on intercontinental routes over the oceans, at least in terms of coverage. However, for short- and medium-haul continental flights, a satellite-based solution is relatively costly; the equipment is heavy, bulky and expensive, latency is high, and capacity is shared in regions with heavy air traffic. Ka band and Ku band satellite antennas are difficult to install on continental aircraft, requiring significant investments in aircraft infrastructure. Additionally, while Ka band satellite solutions might provide similar data rates to the aircraft as ATG, they entail a large transmission path from the aircraft to their geostationary orbits 36,000 kilometers above the Earth – a general hindrance for any latency-critical services. Further, their return links for getting data off the aircraft are significantly limited. This means that many future applications like Internet of Things and real-time aircraft health monitoring will be significantly constrained over a satellite link as compared to the more abundant return link on an ATG system.

The below chart shows how next generation satellite solutions are complimentary to a 4G LTE-based ATG system. Each solution excels at different attributes and both are valuable to IFC depending on the platform and mission.

4G LTE IFC and Satellite are complimentary

Ideal Features for an IFC System	Ka/Ku/ HTS	4G LTE ATG
Hi Speed to Aircraft	√	√
Hi Speed from Aircraft (i.e. for content, aircraft health monitoring, IoT, etc.)	≈	√
Low Latency / Real Time Data	X	√
Worldwide or Near Worldwide Coverage	√	X
Gate to Gate Coverage	√	√
Cost Effective	≈	√
Secure	≈	√
Reliable (rain fade issues)	≈	√
Quick to Install (minimal aircraft downtime)	X	√
Fits all aircraft models	X	√
Has Longevity (scalable, i.e. supports high traffic density,and easily upgradable)	≈	√

10. LTE: The next-generation platform for ATG - LTE is the global standard for the fourth generation (4G) of mobile multimedia broadband communications (data, video and voice). Defined by the global 3rd Generation Partnership Project (3GPP), it has been massively deployed worldwide by many mobile operators. LTE offers interoperability, scalability and high reliability. It also provides low latency (down to less than 100 milliseconds in aviation applications) and high data throughput (theoretical peak speeds can be over a hundred Mb/s). It can also operate in a wide spectrum range including the unlicensed space. As such, it provides a highly efficient and effective platform solution for advanced multimedia services, innumerable mission-critical applications for airlines, and a broad range of devices. Its advanced processing and spectral efficiency provide optimal support for day-to-day operations. Again, it is important to note that RAN and Aircraft based UE are customized for ATG networks . Off the shelf LTE devices will, however, work inside the cabin as long as they connect to the air-interface via Wi-Fi or to an onboard picocell. As such, significant modifications are required to ensure the radio access network, or air-interface link, works. These air link enhancements to the 3GPP version of LTE include range extension and doppler correction, as well as to enable use with high power (to the air) beamforming technology. Once on the ground, the system acts just like and is interoperable with existing LTE infrastructure. Further, in the case of SmartSky's US-based initial deployment in the 2.4 GHz unlicensed band, which is also its frequency preference for a system in India, advanced beamforming technology is needed in order to make the system operate in the 2.4 GHz unlicensed band, due to the need to maintain high performance in the face of 2.4 GHz interference from terrestrial use of the same band, as well as preventing the aircraft's transmission from causing harmful interference to the terrestrial 2.4 GHz users.

11. Secure, mission-critical architecture - LTE-based solutions use an all-IP architecture that, combined with geographic redundancy, reduces potential points of failure and provides the high altitude availability required by airlines and their customers. This also allows operators to build a complete, highly cost effective end-to-end network, including LTE core, backhaul, LTE Radio Access Network (RAN) and modem or end-user devices. Its end-to-end QoS, from the core to the terminal or user, allows services and passenger connectivity on the same infrastructure.

    LTE systems also offer extensive self-optimizing capabilities for simplified network operations, maintenance and self-healing. They are secure by default, with integrated encryption, access control and authentication.

12. LTE Optimized for ATG – On small aircrafts, ATG LTE is the only viable option given the large size and heavy weight of the typical satellite antennas. On larger aircraft, ATG LTE does not need to replace satellite broadband, but will complement it while providing unprecedented levels of performance for in-flight connectivity. The enodeB is designed with specific algorithms for managing the characteristics of air-to-ground operations, including the need to cover large areas (100 to 150 kilometer radius) and the high speeds of jet aircraft operations.

    The onboard aircraft equipment is modular and highly versatile. It includes two to three small antennas mounted below the fuselage, along with a compact and low-weight ATG Aircraft Base Radio Unit (ABR) with a transceiver, acting as a hub and ground interface. SmartSky has developed and flight-tested ABR technology and algorithms that afford high-speed, high-bandwidth communications at high velocity. Even with jets flying at extreme altitudes (SmartSky's system is designed for altitudes up to 15,545 meters) and quick speeds, a fast broadband connection with the ground infrastructure is maintained and handovers between cells are done instantly and seamlessly.

    The ABR supports a wide variety of onboard access technologies. Passenger connectivity is implemented through Wi-Fi. Cellular devices can use Wi-Fi calling features native to the carrier, too. Optionally, a pico-cell could be used for an apparent direct cellular connection from the device (2G, 3G and 4G), and the aircraft entertainment systems as well as flight deck applications which can be connected through Ethernet or wirelessly with appropriate security measures. Several QoS classes in the fully IP-based system ensure compatibility with existing Wi-Fi or GSM On Board Aircraft (GSMOBA) systems, and support future applications and services.

13. To enable a terrestrial-based connection, the ATG LTE network may share the core infrastructure from established cellular networks designed for "normal" terrestrial mobile broadband applications, particularly using existing cell towers and backhaul connections. The cellular structures of typical mobile broadband networks are much denser (ranges up to 10 kilometers), and cannot provide broadband services to aircraft without major interference risks to their own operations, plus the 3GPP standard does not readily accommodate the needed features for reliable service to high altitude, high speed aircraft.

14. ATG LTE is capable of providing 4G LTE-type throughput from aircraft at long ranges from the cell tower at jet speeds with these built-in advantages:

    - A short transmission path compared to satellite technology, along with the low latency of LTE, reduces the delay for the critical services while simplifying system design for best-effort services. Latency is enhanced by the use of geographically optimized, virtualized Evolved Packet Cores and internet gateways.

    - QoS-aware architecture in a fully IP-based system ensures compatibility with existing Wi-Fi or GSMOBA systems, but also supports future applications and services.

    - LTE can be integrated with existing airline networks, as well as with the satellite systems now providing broadband services for international flights.

Conclusion:

1. We are very pleased with the decision of Telecom regulator TRAI having kicked off discussions on the subject by floating a consultation paper that is considering the introduction of in-flight connectivity for voice, data and video services for domestic and international flights as well as planes flying over the Indian airspace.

2. Air-to-ground technology is well-suited to provide broadband connectivity to continental aircraft flights. It has significant technical and cost advantages over existing and future satellite solutions. Commercial off-the-shelf technology, adapted to work in the aviation application, and importantly, in non-dedicated 2.4 GHz spectrum, is required in order to leverage the technology's benefits and thus provide the cost and performance advantages of air-to-ground communications.

3. The Authority should take steps to introduce the newer technologies for In-Flight communication in addition to the Satellite communication.

4. The Authority should compare the benefits of Air-To-Ground technologies with the Satellite communication for In-Flight Communications from both operations and consumer point of view.

ISSUE-WISE RESPONSE:
Our question-wise response is as follows:

Which of the following IFC services be permitted in India?

a. Internet services
b. Mobile Communication services (MCA service)
c. Both, Internet and MCA

SmartSky Response: We recommend TRAI permit both Internet and MCA for IFC services.

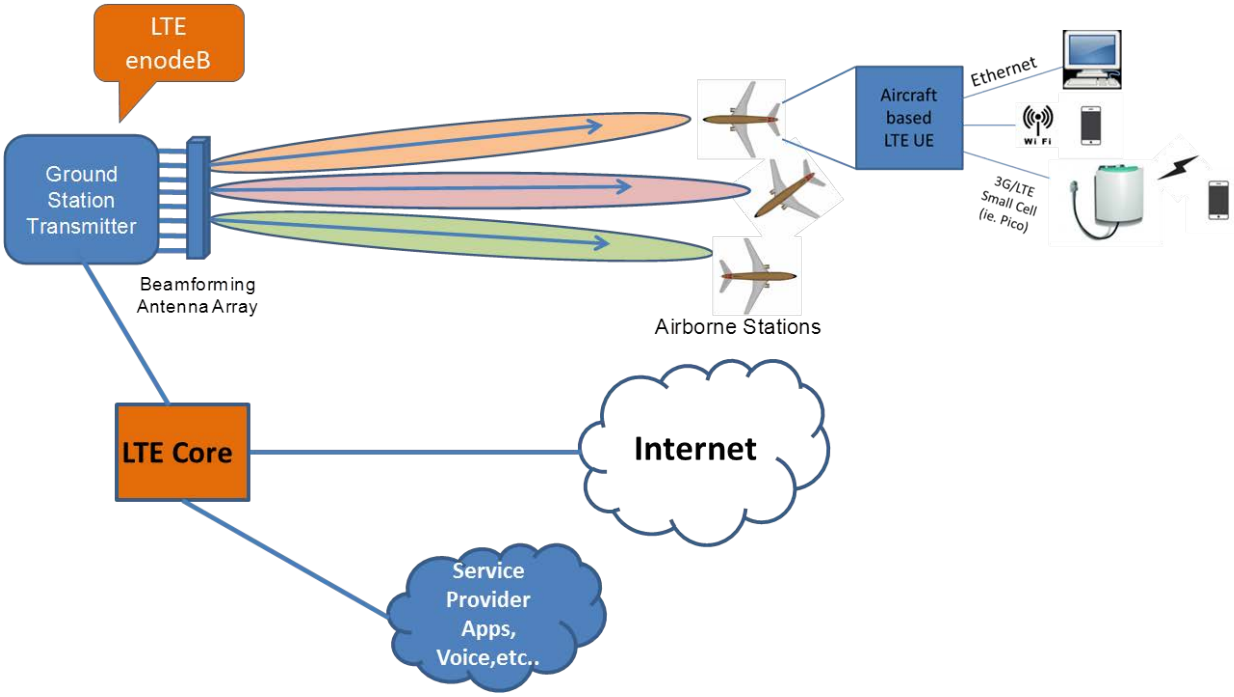
Q.2 Should the global standards of AES/ESIM, shown in Table 2.1, be mandated for the provision of AMSS in Indian airspace?

SmartSky Response: No. We strongly oppose the global standards of AES/ESIM, shown in Table 2.1, for the provision of AMSS in Indian airspace. There are technologies that already exist that do not require the global standards for In-flight Communication.

We urge the Authority of TRAI to look at Air-to-Ground technology as a viable option for IFC. ATG does not use Ku/Ka bands that are for the satellite communications. It can utilize unlicensed band instead with a higher bandwidth that can allow higher throughput and low latency compared to Satellite technologies.

Air-to-Ground (ATG) broadband network is a network of cell towers on the ground. These cell towers are terrestrial radio towers with network that transmits the signal to the aircraft as it travels.

SmartSky's ATG network is based on 4G cellular Long-Term Evolution (LTE) technology. This network will utilize ground stations connecting with aircraft flying overhead, providing an ultra-broadband backhaul infrastructure for deploying high-bandwidth in-flight connectivity to passengers and crew. While their customers and employees alike are enjoying these services, airlines will benefit from cost efficiencies and competitive offerings.



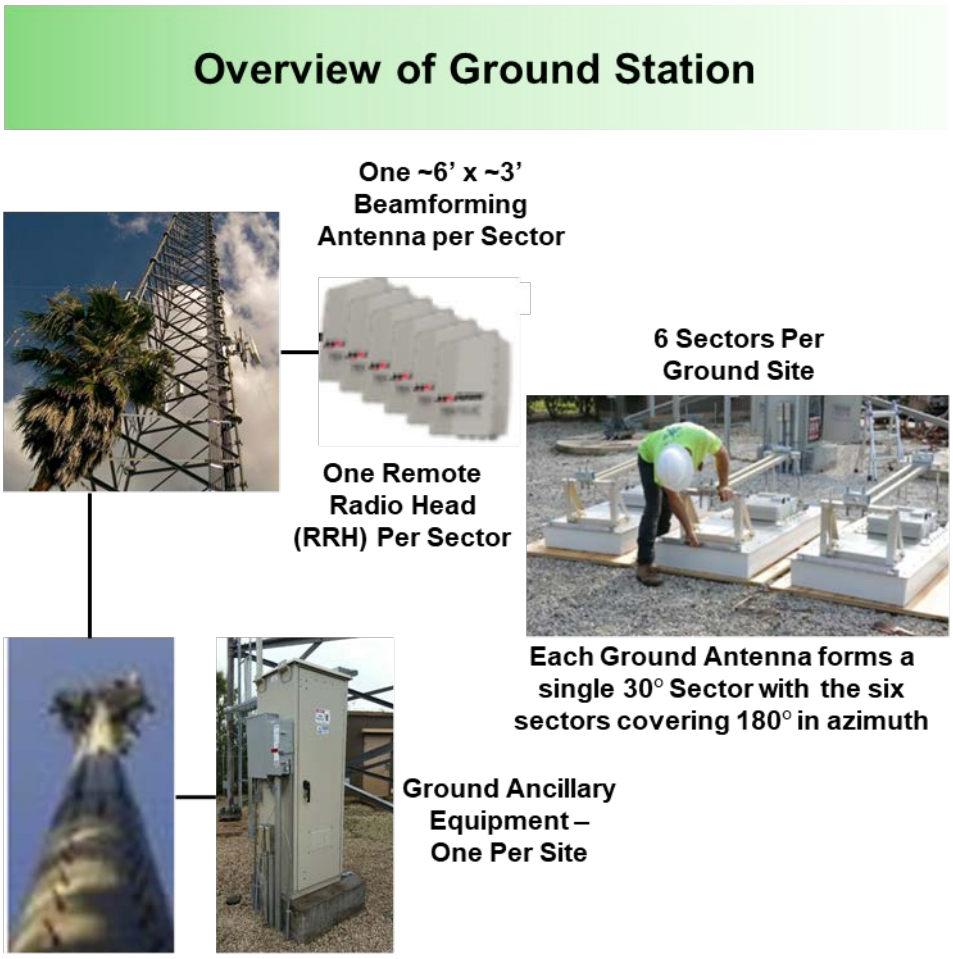
Example of ATG In-Flight Architecture

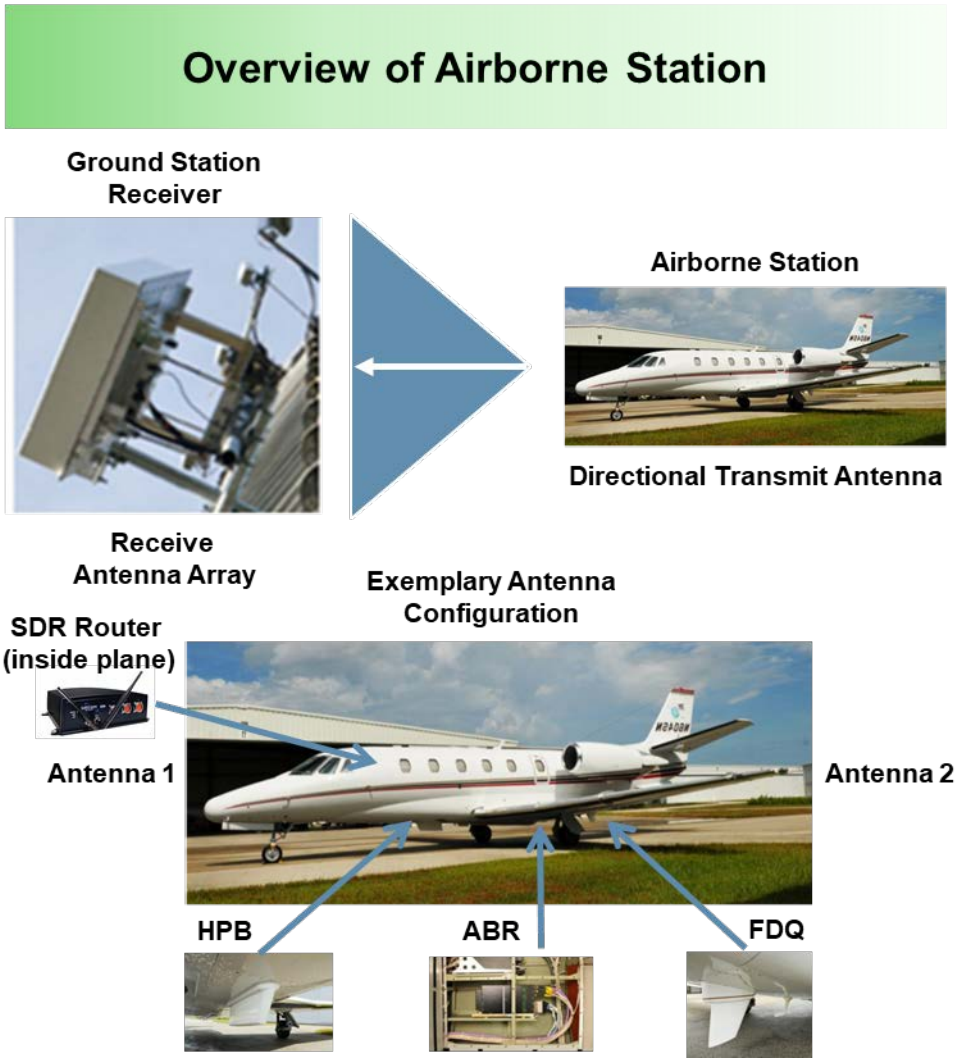
Architecture of the ATG solution is presented in the example above. It relies on the following elements:

- **LTE Cell Site/enodeB**: To be located on the ground, which is similar to a terrestrial LTE cellular network to cover flight path.
- **Ground Data Center**: consists of LTE EPC Core (MME/SAEGW), and LTE support infrastructure (HSS/PCRF/EIR etc.), networked routers, switches, servers and firewall security devices. Servers in data centers are used for hosting in-flight as well as ground IT systems including applications and portals.
- **Aircraft based LTE UE and supporting network**: a network in the aircraft, where data is distributed through the local Wi-Fi network that is maintained by airborne system. ATG Antennas are typically mounted on the bottom of the aircraft.

Cost of installation and maintenance is lower compared to satellite solutions and provides complete flight path coverage within India. This solution is most suitable for Domestic flights providing the bandwidth and data rates comparable to terrestrial LTE/4G networks. Furthermore, we expect that ATG and Satellite solutions to co-exist. Satellite solution provide coverage over larger area enabling services for transoceanic routes. However, the initial costs of satellite installation are high and is generally a higher latency solution.

Examples of SmartSky's US based installations and demonstration aircraft:





Q.3 If MCA services are permitted in Indian airspace, what measures should be adopted to prevent an airborne mobile phone from interfering with terrestrial cellular mobile network? Should it be made technology and frequency neutral or restricted to GSM services in the 1800 MHz frequency band, UMTS in the 2100 MHz band and LTE in the 1800 MHz band in line with EU regulations?

SmartSky Response: SmartSky strongly recommends authority to explore technology solutions that use unlicensed spectrum (e.g., 2.4GHz) such as ATG over 2.4GHz spectrum using beamforming technology.

The 2.4 GHz unlicensed band is fairly universal and, if the rules in India can be made to mirror those of the US Federal Communication Commission's regulations (47 CFR Section 15.247) which address the use of beamforming systems in the unlicensed 2.4 GHz band, then India could have a system whereby the 2.4 GHz band could be used, simultaneously, both in the air and on the ground, just like

the system being deployed right now in the US. Also, given the equipment for the US network has already passed its FCC certification testing and the airborne equipment is already being certified for many aircraft models, the ability to quickly and cost-effectively deploy an ATG network in India would be greatly enhanced. SmartSky has similar projects underway in various other international geographies, such that the system would also be compatible with that infrastructure, as well.

Q.4 Do you foresee any challenges, if the internet services be made available 'gate to gate' i.e. from the boarding gate of the departure airport until the disembarking gate at the arrival airport?

SmartSky Response: Technology challenges are not foreseen. However, passenger safety/security needs to evaluated. SmartSky's initial network implementation is designed to guarantee coverage above 3,000 meters, with gate to gate and low altitude coverage (in the vicinity of airports) being on SmartSky's roadmap.

Q.5 Whether the Unified Licensee having authorization for Access Service/Internet Service (Cat-A) be permitted to provide IFC services in Indian airspace in airlines registered in India?

SmartSky Response: It is highly desirable that Airlines in India be allowed to offer mobile telephony and internet services on flights.

With this, Indian airlines/carriers will join a club of more than 30 airlines, including British Airways, Singapore Airlines, Emirates, Qatar Airways and Virgin Atlantic, that allow passengers to use mobile phones and surf the Net during a flight.

We are very pleased with the decision of Telecom regulator TRAI having kicked off discussions on the subject by floating a consultation paper that looks at the possibility of introducing in-flight connectivity for voice, data and video services for domestic and international flights as well as planes flying over the Indian airspace.

With this much-awaited move, as TRAI's paper states, "It is possible for the passengers to have telecom services in the aircraft travelling at 800 km per hour and 10,000 meters in the sky due to satellite-enabled connectivity," but also because of latest state of the art ATG LTE enabled connectivity. As technologies to provide such access have developed, so too have consumers' expectations. They desire seamless connectivity regardless of their location - whether on land, in the air or on the sea.

With regards to this service being offered under unified license like the telecom operators. It is highly desirable to leave the choice to the existing operators having unified licensee in India to offer IFC either by using satellite system or LTE solution. By allowing a technology agnostic solution, it makes deployment simpler and faster as majority of the network infrastructure is already in place and most importantly all the service providers have lawful interception which addresses the security concern.

Q.6 Whether a separate category of IFC Service Provider be created to permit IFC services in Indian airspace in airlines registered in India?

SmartSky Response: It may not be necessary to create a separate service provider instead, existing telecom operators with unified license to offer IFC can leverage the existing LTE network infrastructure.

Q.7 Whether an IFC service provider be permitted to provide IFC services, after entering into an agreement with Unified Licensee having appropriate authorization, in Indian airspace in airlines registered in India?

SmartSky Response: Not necessary, for a new entrant the cost of setting up a separate network exclusively for IFC may not be viable business model. In the United States, SmartSky's network leverages most of the existing cellular network infrastructure, including backhaul, cell towers, data centers, etc. The only unique aspect of the network is the equipment installed locally at each cell tower (ground cabinet, radios, antennas) and virtualized evolved packet cores in the data centers.

Q.8 If response to Q.7 is YES, is there any need for separate permission to be taken by IFC service providers from DoT to offer IFC service in Indian airspace in Indian registered airlines? Should they be required to register with DoT? In such a scenario, what should be the broad requirements for the fulfillment of registration process?

SmartSky Response: Not applicable as the answer to question 7 is "No".

Q.9 If an IFC service provider be permitted to provide IFC services in agreement with Unified Licensee having appropriate authorization in airlines registered in India, which authorization holder can be permitted to tie up with an IFC service provider to offer IFC service in Indian airspace?

SmartSky Response: Not Recommended.

Q.10 What other restrictions/regulations should be in place for the provision of IFC in the airlines registered in India.

SmartSky Response: Certification from the respective aircraft manufacturer, or supplemental type certifications developed and certified by qualified aftermarket maintenance, repair, and overhaul facilities. If India is willing to accept FAA and/or FCC certifications as equivalent to compliance with India's requirements, that would greatly enhance the speed (likely by years) with which the technology could be deployed to Indian aircraft, be they airlines or business aircraft.

Q.11 What restrictions/regulations should be in place for the provision of IFC in the foreign airlines? Should the regulatory requirements be any different for an IFC service provider to offer IFC services in Indian airspace in airlines

registered outside India vis-à-vis those if IFC services are provided in Indian registered airlines?

SmartSky Response: We do not recommend any special restrictions. To the extent foreign airlines connect to an Indian ATG system, India could earn tax revenue in the same manner as for solely domestic operations. In that way, the more aircraft that are equipped and allowed to offer IFC over Indian airspace the better it will be for both India and the IFC provider.

Q.12 Do you agree that the permission for the provision of IFC services can be given by making rules under Section 4 of Indian Telegraph Act, 1885?

SmartSky Response: In the interest of speedy decision and execution of the IFC service here in India, it is recommended that existing telecom operators with unified license to offer IFC leverage the existing LTE network infrastructure or a satellite service provider.

Q.13 Which of the options discussed in Para 3.19 to 3.22 should be mandated to ensure control over the usage on IFC when the aircraft is in Indian airspace?

SmartSky Response: ATG technology uses LTE/4G 3gpp Lawful Intercept thus eliminating the need to define new standards. The ATG networks in the US are compliant with lawful intercept and the same would be true for operations in Indian airspace.

Q.14 Should the IFC operations in the domestic flights be permitted only through INSAT system (including foreign satellite system leased through DOS)?

SmartSky Response: No. The IFC service offering should be technology agnostic, leverage either existing LTE technology with IFC access network in unlicensed band, i.e. 2.4 GHz, or Satellite technology in Ka or Ku band or other bands as may be available now or in the future. Pre-defining the operating band and technology is not advised. Rather, the more technology and band-agnostic the rules, the better to encourage innovation and competition. However, SmartSky does recommend establishing the allowance of some initial frequencies to use for IFC, such as 2.4 GHz, Ku, and Ka band since those are the prevalent worldwide technologies right now.

Q.15 Should the IFC operations in international flights (both Indian registered as well as foreign airlines) flying over multiple jurisdictions be permitted to use either INSAT System or foreign satellite system in Indian airspace?

SmartSky Response: Not Applicable for ATG. An IFC service offering should be technology agnostic leveraging either existing LTE technology with IFC access network in unlicensed band, i.e. 2.4 GHz, or Satellite technology in Ka or Ku band.

Q.16 Please suggest how the IFC service providers be charged in the following cases?
(a) Foreign registered airlines.

(b) Indian registered airlines.

SmartSky Response: ATG is built on the 3gpp based billing system. It is flexible in addressing multilayered charging. Actual charging models will vary, largely based on Airline/IFC service provider preferences and the market dynamics. Predetermining the charging mechanism will limit and discourage innovation. Pricing models should be market based and thus competitive in nature. Examples of models being tried on airlines in various parts of the world right now include: free (to passengers), hotel model (low or no cost basic internet access, higher price for streaming services), retail model, wholesale model, sponsorship model, multi-tiered models, etc.

Q.17 Should satellite frequency spectrum bands be specified for the provisioning of the IFC services or spectrum neutral approach be adopted?

SmartSky Response: Not Applicable for ATG technology.
Currently, most in-flight connectivity uses satellite backhaul, with one vendor operating a satellite/ ground Internet system in North America. For short- and medium-haul continental flights, these systems tend to be bulky and expensive. Additionally, current capacity is limited and exhibits high latency, especially when serving a large number of continental aircraft in a limited geographic area. See Q3 for SmartSky's recommendation relative to ATG frequency, namely to re-use the unlicensed 2.4 GHz band and thus maximize the utility of existing spectrum.

Q.18 If stakeholders are of the view that IFC services be permitted only in specified satellite frequency bands, which frequency spectrum bands should be specified for this purpose?

SmartSky Response: We strongly urge the Authority of India to consider an Air-to-Ground system which does not even use satellite frequency bands. Again, as stated in Q3, SmartSky recommends India adopt regulations favorable to the use of unlicensed bands with beamforming rules like that of the US and elsewhere, particularly at 2.4 GHz, but additionally could consider doing the same at 5.8 GHz.