WP5D/XX
20 Sept 2024
English only

GENERAL ASPECTS

IAFI[1]

FURTHER UPDATES TO THE WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT A NEW REPORT ITU-R M.[IMT.A2G]

1 Introduction

45th meeting of the WP-5D started work on development of a new Report ITU-R M.[IMT.A2G based on a proposal from China (5D/36) with the title of "Non-safety communications between base stations on ground and airborne user equipment devices supported by the terrestrial component of IMT" (Annexure-3.2 Chair's report/5D/77).

During 46th WP-5D meeting three more contributions (5D/141-Russian Federation, 148-China and 176 – Mexico) were discussed and a skeleton working document was developed for further study (Annexure -3.3 of 46th WP-5D Chair's report/242-E).

2 Proposal

IAFI through this contribution provides additional background information on how IMT-2020 can provide a reliable, high-speed and affordable internet experience to passengers during fight, through ATG systems. This technology empowers airlines to enhance passenger satisfaction, unlock new revenue streams, and improve operational efficiency. As standards evolve and technology progresses, IMT-2020 and its successors will continue to revolutionize air-to-ground communications, shaping the future of in-flight experiences and operational efficiency. IAFI suggest for incorporating the contents of this contribution in the report suitably.

[1] ITU-APT Foundation of India (IAFI) is a sector member of the ITU

RECENT DEVELOPMENTS IN THE USE OF IMT-ADVANCED AND IMT-2020 FOR AIR-TO-GROUND COMMUNICATIONS

Introduction

Air-to-ground (ATG) network refers to in-flight connectivity technique, using ground-based cell towers that send signals up to an aircraft's antenna(s) of onboard ATG terminal. As a plane travels into different sections of airspace, the onboard ATG terminal automatically connects to the cell with strongest received signal power, just as a mobile phone does on the ground. In this network, a direct radio link will be established between Base Station (BS) on the ground and Customer Premises Equipment (CPE like antenna, modem, Wi-Fi router, etc.) mounted on the aircraft.

Air-to-ground (ATG) communications play an increasingly important role in modern aviation, particularly with the growing demand for in-flight connectivity. Passengers expect reliable internet access while flying, which has driven innovation in ATG communication technologies. One significant advancement in this field is the use of IMT-advanced and IMT-2020 technologies, especially under the framework of the International Mobile Telecommunications Air-to-Ground (IMT ATG) systems. These developments represent a fundamental shift from traditional satellite-based communications to more efficient, high-speed connections that provide significant benefits in terms of both performance and cost.

This article explores the role of IMT-advanced and IMT-2020 in ATG communications, focusing on how IMT ATG enables in-flight connectivity by establishing communication links between terrestrial IMT base stations (BS) and on-board ATG units mounted on aircraft. It also highlights the emerging standards, such as those set forth in 3GPP TR 38.876 V18.2.0, and discusses key trends in the aviation industry.

IMT ATG: A New Frontier in In-Flight Connectivity

IMT ATG is an innovative approach to providing broadband connectivity to passengers during flights. This technology establishes a communication link between a terrestrial IMT base station and an On-Board ATG IMT Unit (OBI) that is mounted on the aircraft. The OBI, also referred to as ATG UE (User Equipment) in some technical contexts, acts as customer premises equipment (CPE) mounted on the aircraft's exterior. The OBI includes an external antenna, typically positioned at the bottom of the aircraft to facilitate reliable communication with terrestrial base stations. The use of IMT-advanced and IMT-2020 for air-to-ground connectivity offers several advantages over legacy systems, including higher data speeds, lower latency, and greater network capacity .One key feature of the IMT ATG system is its ability to provide broadband connectivity within the cabin of passenger aircraft. This is achieved by deploying an on-board microcell or access point (AP) that connects to the OBI through a wired connection. The microcell or AP then creates a Wi-Fi network inside the cabin, enabling passengers to use devices such as smartphones, laptops, and tablets as they would on the ground. However, it is worth noting that communication links within the cabin are out of the scope of the ITU-R report.

The Role of IMT-advanced in Air-to-Ground Communications

The introduction of IMT-advanced technology into ATG communications has been a game-changer in the aviation industry. Compared to older 2G and 3G networks, IMT-advanced offers significantly faster download and upload speeds, making it more suitable for delivering high-quality in-flight broadband services. IMT-advanced networks rely on LTE (Long-Term Evolution) technology, which enables the transmission of high-speed data over large distances. In the context of air-to-ground communications, LTE-based systems are used to maintain continuous connectivity between an aircraft and terrestrial base stations. This is particularly challenging due to the high speeds at which airplanes travel, as well as the altitude at which they operate. Several countries, including the United States and parts of Europe, have already deployed IMT-advanced-based ATG networks for commercial flights. For example, one company's ATG network in the United States relies on a IMT-advanced LTE system that delivers in-flight Wi-Fi to millions of passengers each year. However, while IMT-advanced has been instrumental in advancing in-flight connectivity, it is increasingly being complemented—and in some cases replaced—by IMT-2020 technology.

The Advent of IMT-2020 for Air-to-Ground Communications

IMT-2020 technology represents the next major step in air-to-ground communications, offering even greater speed, lower latency, and the ability to connect more devices simultaneously. Unlike IMT-advanced, which is primarily designed for consumer data, IMT-2020 is optimized for a broader range of applications, including machine-to-machine communication, real-time data processing, and the Internet of Things (IoT). The IMT ATG system, when integrated with IMT-2020, allows for higher data rates, improved spectral efficiency, and better coverage for aircraft flying at high altitudes. This is achieved through advanced features such as beamforming and massive MIMO (Multiple Input, Multiple Output), which enable IMT-2020 networks to transmit signals more efficiently and over longer distances than IMT-advanced networks. In addition to improving passenger connectivity, IMT-2020 also opens up new possibilities for operational efficiency in aviation. Aircraft equipped with IMT-2020-enabled ATG systems can transmit real-time data about their performance to ground stations, allowing airlines to optimize flight paths, monitor engine health, and enhance safety.

IMT ATG and 3GPP Standards

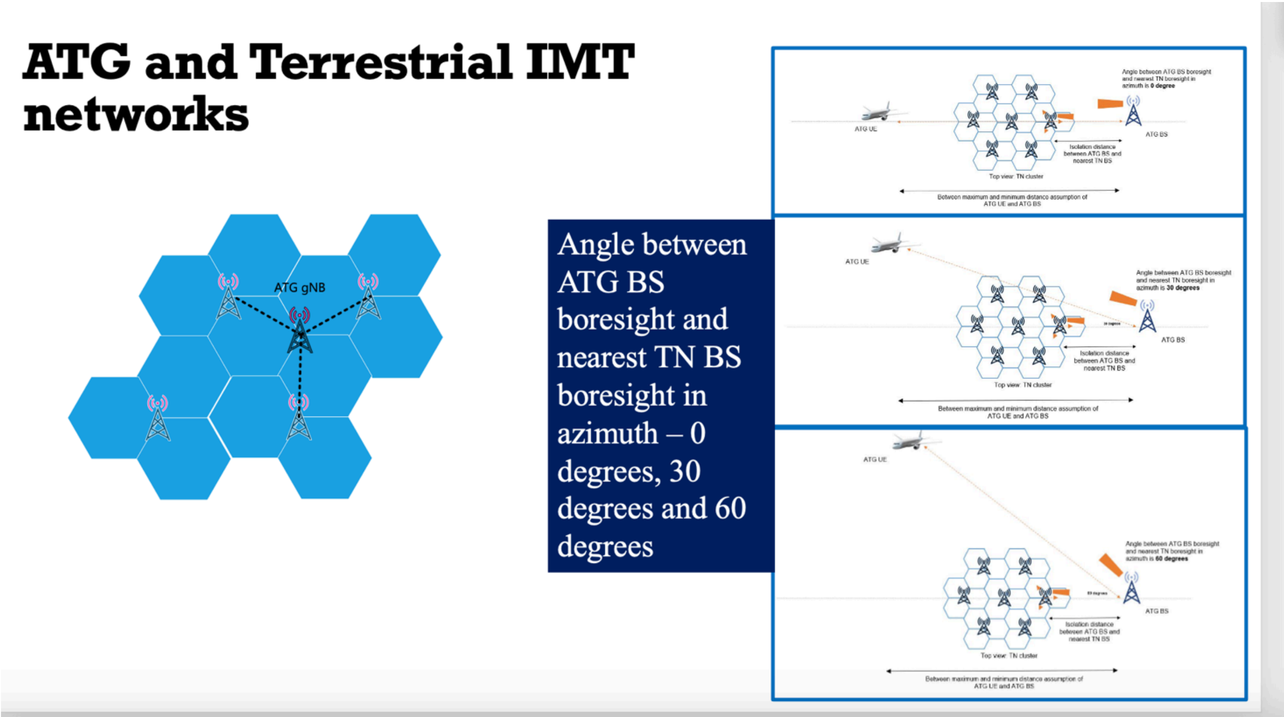
The IMT ATG system is being standardized by the 3rd Generation Partnership Project (3GPP), a global initiative that develops telecommunications standards. The most recent technical report, 3GPP TR 38.876 V18.2.0, outlines the key specifications for ATG systems, including the use of IMT-2020 technology in this context. According to the report, the OBI (or ATG UE) is designed to function as customer premises equipment, which establishes and maintains the communication link between the aircraft and the terrestrial IMT base station. One of the primary challenges addressed by the 3GPP standards is the need to maintain a stable connection despite the high speeds and altitudes at which aircraft operate. To overcome this, IMT-2020 ATG systems make use of advanced techniques such as carrier aggregation, which allows multiple frequency bands to be used simultaneously, and seamless handover, which ensures that the connection remains uninterrupted as the aircraft moves between coverage areas.

From various trials and commercial operation [https://inflight.telekom.net/ean/] of adapted LTE ATG solutions, the following characteristics are considered by the 3GPP for ATG network deployment scenarios.

a) Extremely large inter-site distance (ISD) and large coverage range: In order to control the network deployment cost and considering the limited number of flights, large ISD is preferred, e.g., about 100km to 200km. At the same time, when the plane is above the sea, the distance between the plane and the nearest base station could be more than 200km and even up to 300km. Therefore, ATG network should be able to provide up to 300km cell coverage range.

b) Utilizing non-disjoint frequency for deploying both ATG and terrestrial networks, i.e. same operating band but ATG network and TN use adjacent carriers: Operators are interested to adopt the same frequency for deploying both ATG and terrestrial networks to save frequency resource cost, while interference between ATG and terrestrial networks becomes non-negligible and should be addressed.

c) Much powerful on-board ATG terminal capacity: On-board ATG terminal can be much powerful than normal terrestrial UE, e.g., with higher EIRP via much larger transmission power and/or much larger on-board antenna gain.



5 ATG bands

ATG systems operate within existing IMT operating bands and does not need new bands. Depending on the operator's request so far, the following IMT bands are intended for ATG deployment in 3GPP Rel-18. Other new band request for ATG deployment is not precluded in future.

Table 5-1: ATG operating bands

3GPP NR operating band	Uplink (UL) *operating band* BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) *operating band* BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
n1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
n3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
n34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
n39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
n41	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
n78	3300 MHz – 3800 MHz	3300 MHz – 3800 MHz	TDD
n79	4400 MHz – 5000 MHz	4400 MHz – 5000 MHz	TDD

Challenges and Future Prospects

Despite the significant progress made in the development of IMT-advanced and IMT-2020 ATG systems, several challenges remain. One of the primary concerns is the availability of spectrum for ATG communications. As more devices and services compete for access to radio frequencies, ensuring that there is sufficient bandwidth for high-speed in-flight connectivity will be crucial. Another challenge is the cost of deploying ATG infrastructure. Installing base stations capable of communicating with aircraft at high altitudes requires significant investment, particularly in rural or remote areas where existing infrastructure may be lacking. Looking to the future, the continued development of IMT-2020 and beyond-IMT-2020 technologies promises to further enhance the capabilities of air-to-ground communication systems. With the potential for faster data rates, lower latency, and greater network reliability, these technologies will play a key role in meeting the growing demand for in-flight connectivity in the coming decades.

References

1. **3GPP TR 38.876 V18.2.0 (Technical Specification)**
   This technical report outlines the use of 5G in air-to-ground communications, including detailed specifications for IMT ATG systems.
   - **3GPP TR 38.876 V18.2.0**
2. **Gogo Air: Air-to-Ground Networks**
   Gogo is a major player in ATG communications and provides extensive details on their 4G LTE-based ATG network used in commercial aviation.
   - **Gogo ATG Networks**
3. **Inmarsat Aviation – European Aviation Network (EAN)**
   Inmarsat and Deutsche Telekom’s European Aviation Network (EAN) is a hybrid satellite and ATG system offering a good case study for current ATG solutions.
   - **European Aviation Network (EAN)**
4. **Qualcomm’s 5G in Aviation**
   Qualcomm is one of the pioneers in mobile technology and has been developing 5G use cases in aviation, including ATG applications.
   - **Qualcomm’s 5G Aviation Page**
5. **Honeywell Aerospace – Connectivity Solutions**
   Honeywell offers solutions for in-flight connectivity and has been heavily involved in developing 5G-ready systems for aviation.
   - **Honeywell Aerospace Connectivity**

6. **EASA (European Union Aviation Safety Agency) Research on Wireless Communications**
   EASA regularly publishes studies on the use of wireless communications, including the use of 4G and 5G technologies in aviation.

   - **EASA Wireless Communications**

7. **IEEE Xplore Digital Library**
   IEEE offers a wide range of research papers and technical articles on 4G/5G air-to-ground communications and aviation technologies.

- **IEEE Xplore: 5G Aviation**

Conclusion

The integration of IMT-advanced and IMT-2020 technologies into air-to-ground communication systems marks a major advancement in the field of in-flight connectivity. IMT ATG systems, which establish communication links between terrestrial IMT base stations and on-board units in aircraft, offer a promising solution for providing high-speed internet access to passengers. As standards continue to evolve and more airlines adopt these technologies, passengers can expect increasingly reliable and high-quality connectivity during flights. In the years ahead, the continued development of IMT-2020 and the eventual transition to 6G will further revolutionize air-to-ground communications, opening up new possibilities for both passengers and airline operations.