Spectrum and regulatory challenges related to eVTOLs

Electronic Vertical Take-Off and Landing (eVTOL) aircraft are expected to begin commercial operations as early then end of 2025 and will become part of the mainstream aviation sector in the 2030s. eVTOL's will rely on access to radio spectrum to support a range of critical systems and these requirements create a unique set of issues and challenges for forward looking telecoms regulators. This paper explores some of the issues and challenges.

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Spectrum framework and regulatory readiness for eVTOL operations

Introduction

Electric Vertical Take-Off and Landing aircraft are expected to begin commercial operations as early as 2026

Electric Vertical Take-Off and Landing (eVTOL) aircraft, designed to provide, for example air taxi services, may seem futuristic but they are expected to be a mainstream part of the transport ecosystem from the late 2020s. eVTOL operator Joby is expected to launch an air taxi services in the UAE by early 2026, with Joby targeting initial operations as early as 2025. Another operator, Archer, was selected to be the official air taxi service provider for the Los Angeles 2028 Olympic games.

The rapid development presents a range of challenges for national regulators, not least telecoms regulators responsible for managing the spectrum that eVTOL technologies will rely

As eVTOL technologies are rapidly evolving, this presents a range of challenges for national regulators, not least telecoms regulators responsible for managing the spectrum resources upon which many of the eVTOL technologies related to communication, navigation and safety relay. The challenges range from making available suitable frequency bands, integrating 5G, AI and IoT systems, to ensuring cybersecurity, managing low-altitude traffic and aligning aviation and telecom regulations. Without a proactive and coordinated approach, poor spectrum allocations and outdated regulatory frameworks could hinder adoption and innovation within the sector.

Coleago recently partnered with leading academics from Cranfield University to explore the spectrum and regulatory issues and challenges related to the rapid development of the eVTOL space. This paper highlights the main issues and challenges regulators will have to address to support this rapidly growing and evolving element of the aviation sector.

Challenges and issues

The safe and efficient operation of eVTOL aircraft relies heavily on access to suitable spectrum bands for a critical range of systems

The safe and efficient operation of eVTOL aircraft relies heavily on access to suitable spectrum bands for command and control, navigation, tactical detect-and-avoid, air traffic management unmanned traffic management (UTM) and data / pay load transmission. Key challenges include:

- Identifying harmonised bands: Globally harmonised spectrum for eVTOLs does not yet exist, leading to potential cross-border and inter-service interference issues.
- High reliability and low latency: Detect-and-avoid systems require sub-1 millisecond latency and 99.999% reliability which requires effective integration with relevant communication networks.
- New geographic zoning for spectrum: Traditional cellular cell-based coverage with limited aerial radiation may not be suitable for drone corridors and urban low-altitude propagation. Balancing inter-cell interference and drone coverage is crucial.
- Shared use and licensing models: A wide range of licensing models exist and selecting the appropriate model to ensure spectrum is used efficiently and without interference in congested urban environments will be challenging.

Regulatory framework development

A lack of mature regulatory standards for eVTOLs presents one of the most significant implementation barriers

A lack of mature regulatory standards for eVTOLs presents one of the most significant implementation barriers. Whilst best practice for IMT spectrum management is well-established and documented, this is not the case for eVTOLs. Key issues that will have to be considered are:

- Absence of local and regional standards: The UAE, as with most countries, currently has no comprehensive regulatory framework specific to eVTOLs and our initial research indicates that there are no regional standards.

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- Interference with existing users: eVTOLs are likely to operate from urban vertiports in urban/suburban areas. These are typically congested with various other spectrum use/users and require addressing interference with traditional aviation radars, Cellular, Digital broadcasting, astronomy observations and others.
- Cellular and Air-to-ground: Cellular networks were designed for terrestrial operation, if and where use of cellular frequencies is considered for air-to-ground or V2X comms, additional considerations need to be applied in respect of interference with adjacent spectrum users and licensing conditions in respect to the use of cellular comms at altitude.
- A risk-based approach to operations requiring dedicated spectrum: eVTOLs carrying people and/or valuable goods over densely populated urban areas under traditional aviation operation rules will require enhanced safety standards for C2. Emergency communications, electronic conspicuity etc. will require dedicated spectrum to ensure ultra reliable and low latency connectivity.
- Certification and licensing: The TDRA will want to ensure harmonisation of any policy framework with global standards established by organisations such as the European Union Aviation Safety Agency (EASA), the Federal Aviation Authority of the US (FAA) and regionally, with other aviation authorities in the Middle East.
- Avoiding regulatory silos: A key element of stakeholder engagement will be in ensuring cross-sector coordination between the TDRA, GCAA and the Integrated Transport Centre (ITC) in Abu Dhabi as well as municipal authorities.

In the case of Europe, EASA's "Special Condition for VTOL" allows progressive type certification while maintaining safety objectives. In Singapore, the Civil Aviation Authority is actively collaborating with regional regulators to develop adaptable eVTOL regulatory structures.

Technology integration and network interoperability

eVTOL platforms depend on an integrated communications ecosystem combining terrestrial 5G, satellite and aviation-specific systems

eVTOL platforms depend on an integrated communications ecosystem combining terrestrial 5G, satellite and aviation-specific systems. The critical safety requirements for eVTOL will require a high level of network interoperability with a focus on resilience. Key issues include.

- Hyperconnected Air Traffic Management (ATM): ATM requires continuous, high-integrity data streams to support autonomous routing and congestion management which can only be delivered by networks relying on the use of radio spectrum. The performance requirements of ATM will result in the potential demand for significant amounts of bandwidth and hence spectrum.
- Multi-network handover: eVTOLs will require continuous coverage geographically and in terms of elevation which will require seamless switching between different vertical networks (e.g., between cellular and satellite) and achieving uninterrupted coverage and seamless handovers is technically challenging. There may be fundamental shifts as we move closer to vertical network integration and shared spectrum management in non-terrestrial networking (NTN).
- Hardware standardisation: The business models to support the success of eVTOLs will require a high level of interoperability in eVTOL systems across vendors and regions to ensure sufficient economies of scale in manufacture to support a viable business model and industry. However, the challenge in relation to hardware is that whilst the design features of an aeroplane or helicopter have not changed dramatically for decades, there is likely to be a wide range of different eVTOL designs. This creates problems in terms of the antenna systems as an antenna array that functions well on one type of craft, might not be compatible with other craft with a materially different design.

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Sweden's Teracom demonstrated 5G-based aerial coverage supporting stable, low-interruption flight at distances over 90 km. In the US, FAA trials incorporated 5G networks as non-critical communication layers to enhance overall system resilience.

Cybersecurity and privacy

The increased reliance that eVTOLs will place on networked communications raises new risks

The increased reliance that eVTOLs will place on networked communications raises new risks that will have to be considered:

- Signal jamming and spoofing: Aerial platforms are vulnerable to malicious interference which could result in potentially fatal consequences.
- Unauthorised access: The risk of hijacking or remote manipulation of aircraft over wireless networks presents a significant threat which must be addressed.
- Sensitive data transmission: Ensuring data protection and national security will remain paramount. This includes traceability of data between multiple and potentially competing stakeholders.

EASA's guidelines for using public mobile networks require cybersecurity fallback protocols and dual-redundancy architectures. The European Union Agency for Cybersecurity (ENISA) and 3GPP have developed 5G security baselines, however, their adaptation for eVTOLs is still in development.

Institutional and stakeholder coordination

A successful spectrum framework implementation requires unified oversight and effective collaboration among stakeholders

A successful spectrum framework implementation requires unified oversight and effective collaboration among stakeholders:

- Cross-sector governance: The regulation eVTOLs falls under the scope of a number of regulatory agencies and so it will be important to provide clarity as to which agency regulate what aspects.
- Stakeholder engagement: eVTOL operators, telecommunication operators, regulators and city planners, to identify only a small number of potential stakeholders, must collaborate from the outset but potentially conflicting goals and agendas may challenge the engagement process.

Example: The EU's "U-Space" initiative is a system designed to manage drone traffic and ensure safe, efficient, and secure access to airspace for a large number of Unmanned Aircraft Systems (UAS). It relies on a high level of digitalisation and automation of functions to achieve these goals. Essentially, U-space is a European traffic management system for drones, enabling a large number of operations, many of them simultaneous, while harmoniously coexisting with the existing air traffic management system. India's Taskforce on Short-Haul Mobility involves public and private entities developing joint roadmaps to support eVTOL's with a long-term vision of helping to alleviate the major congestion issues confronting many of India's cities.

Public acceptance and confidence

Growth in the use of drones and eVTOLs will require a high level of public confidence

Growth in the use of drones and eVTOLs will require a high level of public confidence if the technology is to be embraced. Safety will be the primary concern, but the public will also be concerned with noise and visual pollution.

- Noise and visual pollution: Public concerns may stall implementation in dense urban areas.
- Transparency and engagement: The public will need to understand flight paths, safety features and noise abatement strategies if eVTOLs are to be accepted as part of the wider transport system.

Paris City Council initially resisted eVTOL demonstrations despite national support due to concerns regarding the impact of urban citizens. Sweden lifted no-fly zones after successful community engagement and safety trials showed minimal disruption.

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Early examples of regulatory initiatives

Examples of approaches to spectrum management include the European Conference of Postal and Telecommunications Administrations (CEPT) which has proposed using 2 GHz spectrum to support HD video and command and control (C2) links for eVTOLs. Sweden's PTS supported trials integrating terrestrial and satellite networks for an eVTOL flight between Stockholm and Uppsala. Ofcom's 'Spectrum Approaches' in spectrum management need to also be coupled with existing and emerging cellular technologies such as antenna vertical separation (e.g., top layer of antenna pattern and spectrum for unmanned aircraft systems' authorising the use of radio equipment on UAS, particularly relevant for unlocking commercial opportunities requiring Beyond Visual Line of Sight (BVLOS) operations drones) and interference cancellation.

How Coleago can help

Coleago has over 20 years of experience in advising both operators and regulators on issues related to spectrum including spectrum management strategies, roadmaps, pricing and award process design and implementation, including auctions. Our consultants have been closely involved in the spectrum and regulatory issues associated with drone technology and with our academic partners, have been exploring the issues and challenges within the eVTOL arena. Coleago can provide support in relation to spectrum management, regulatory and licensing frameworks to support eVTOL development.

About the Author and Coleago Consulting Ltd

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