

Frequency Bands for Control and Non Payload Communication with RPAS

UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UACS	Unmanned Aircraft Control Station
VLOS	Visual Line Of Sight
RLOS	Radio Line Of Sight
BRLOS	Beyond Radio Line Of Sight

A UAS is composed of an aerial part, the UAV, a ground section, the UACS, and one or various communication links. These communication links include the RPAS's Payload Communication (PC) link and the Control and Non Payload Communication (CNPC) link.

- The PC includes the data received from the payload as well as the control and status of the payload.

- The CNPC involves all the communications required for a safe flight.

The PC and CNPC need to be distinguished, though they can be carried through the same communication link (this is even recommended for minimizing radio SWaP). In the following we focus on the CNPC data link.

Depending on the type of operation, VLOS/BVLOS/RLOS/BRLOS, the CNPC can be carried by different communication media: **direct radio frequency, terrestrial network** or **satellite network**.

- **Direct Radio Frequency (VLOS/BLOS):** Allows a fast communication with limited range (a few kilometers, depending on the regulation). By using a direct communication, it allows fast exchanges with little latency.
- Leisure RPAS available to the public are commanded through this kind of link. Most of them rely on the popular 2.4 GHz and 5.8 GHz frequency bands though some other frequencies are also available (1.2 GHz, 900 MHz, 433 MHz) each with their pros and cons (range, quality, noise, etc.). These bands belong to the ISM bands family [1] accessible for domestic applications. Other frequencies of the ISM bands may be available depending on the type of application.
- Model aircraft bands can also be used but they vary depending on the country.
- In France, the frequencies available for such communications are defined by the "Autorité de Régulation des Communications Electroniques et des Postes" (ARCEP) and the corresponding tables can be found in the "Tableau National de Répartition des Bandes de Fréquences" [2], in particular in the Annex 7 : parts Ic, III and VIII.
- **Terrestrial Networks (RLOS):** For increased range, the UACS can communicate with the UAV over a certain area through a network of ground antennas. At this time the International Telecommunication Union (ITU) proposed two candidate bands: 960 – 1164 MHz and 5030 – 5091 Mhz. The first for terrestrial communications only, the second to be shared between terrestrial and satellite networks.

- **Satellite Networks (BRLOS):** To remove the range limitation of ground antennas, communication with the RPA can rely on a satellite constellation (e.g. IRIDIUM/SATCOM). To avoid interference with other bands, the ITU focused on the available frequency bands for communication with satellites. In the World Radiocommunication Conference 2015 Final Acts [4], several frequency bands were presented as likely candidates for communication with RPAS in non-segregated spaces (see the Table hereafter).

Frequency	Availability	Direction
10.95-11.2 GHz	Worldwide	space-to-Earth
11.45-11.7 GHz	Worldwide	space-to-Earth
11.7-12.2 GHz	Region 2	space-to-Earth
12.2-12.5 GHz	Region 3	space-to-Earth
12.5-12.75 GHz	Regions 1 and 3	space-to-Earth
19.7-20.2 GHz	Worldwide	space-to-Earth
14-14.47 GHz	Worldwide	Earth-to-space
29.5-30.0 GHz	Worldwide	Earth-to-space

However, the ITU states that it is too early and premature to open these bands to RPAS without preliminary studies.

References :

1. ISM bands, https://en.wikipedia.org/wiki/ISM_band
2. ARCEP, "Tableau National de Répartition des Bandes de Fréquences", ANFR, 2016 (last update).
3. ICAO, "Manual on Remotely Piloted Aircraft Systems (RPAS)", 2015.
4. ITU, "World Radiocommunication Conference 2015 Final Acts", ITU, 2015.