Radio regulation for drones

How REVOsdr untangles a tangled world v.2

Product Knowledge White Paper, 2017

This is a "Oak Dot White Paper", about our detailed technical view on the industry, with the purpose of informing drone manufacturers and integrators

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Foreword

Among the intense life of solving hardware or software bugs, building, testing and measuring, and selling, sometimes there is no time to look into the entangled world of "Regulation". And, further, we have "Industry Standards". When building a drone with several radio links, we need to know where in the map our client is, literally - from a global ITU Region to a local geographical restriction, rules are important to be known, understood and followed. Without that, we cannot sell a radio-based product. In the world of professional drones, for the end-user, such is the first step to accomplish surveying missions, avoid accidents and contribute to a harmonised use of drones.

For data link technology planners and makers in the drone context, one major decision is if a communications standard is to be followed or not. Another decisive step is on the available spectrum, power levels, or other regulatory impositions such as spectrum sharing, modulation, multiple access schemes, sub-channels, duty-cycles.

In preparing our REVOsdr data link for the global professional drone market, for its reliability and flexibility, we need to have it ready to work according to several international and national demands. And the radio world is our oyster!

Regulating radio

Who regulates all

The International Telecommunication Union (ITU) is an UN Specialized Agency. It is based in Geneva, Switzerland, and is a member of the United Nations Development Group. Its members include 193 Member States and almost 800 private-sector entities and academic institutions, considered as Sector Members [source]. Some say that this global international telecommunications network is the largest and most sophisticated engineering feat ever created. "ITU is at the very heart of the ICT sector, brokering agreement on technologies, services, and allocation of global resources like radio-frequency spectrum (…) to create a seamless global communications system that's robust, reliable, and constantly evolving.".

ITU member states are organized into six regional groups, including the European Conference of Postal and Telecommunications Administrations (CEPT) and the Inter-American Telecommunication Commission (CITEL). As far as spectrum allocation is concerned, ITU divides those 193 Member States into Regions 1, 2 and 3. Among other functions, it coordinates the shared global use of the radio spectrum.

From its onset, the ITU has had the mission of standardisation, presently also supporting works to improve telecommunication infrastructure in the developing world, assisting in the development and coordination of worldwide technical standards. The ITU-T Telecommunication Standardization and the ITU-R Radiocommunication Sectors provide standards called "Recommendations", that pass through technical study and focus groups, following a structured revising and approval process. At the end, Recommendations become mandatory when accepted and adopted as part of national law.

Known ITU Standards are JPEG still image coding, H.262 video coding, ISDN and PSTN/3G videoconferencing H.320 and H.324 systems, (x)DSL standards for broadband communications, NTSC and PAL TV systems.

Then, to entangle this further, there are other global standardisation bodies, such as the International Organization for Standardization (ISO), in straight contact with the ITU. In telecoms, standardisation is also put forward by regional institutions as the European Telecommunications Standards Institute (ETSI), or the Institute for Electrical and Electronics Engineers Standards Association (IEEE-SA), to mention some examples. These are Sector Members of the ITU. So is the European Union, the European Space Agency (ESA), and the European Patent Office (EPO). And so are Google, Inc. and Facebook! [source]. CEPT is another ITU Sector Member with an important regional role, through the European Communications Office (ECO) and the Electronic Communications Committee (ECC). Therefore, ITU standards result from a complex but effective network of several hundreds of very relevant industry,

ITU Regions as described in RR 5.3 to RR 5.9

governmental and non-governmental players, fundamentally driven by technical and market priorities

At the European level, ETSI is one of the three standardization bodies officially recognised in the EU and European Free Trade Association (EFTA) countries, dealing with radiocommunications. Examples of ETSI standards are GSM, 3G, 4G, BRAN, or DECT [source].

Regulation, standards and technologies

To simplify this standardisation conundrum in the radio-frequency communications context, we usually consider international ITU Recommendations as "Regulation". ITU's outputs carry more formal international weight than any other communications standards. They are the major global communications standards umbrella. These also pass through the national regulator bodies (as the FCC in the US, ANACOM in Portugal, CMT in Spain, RegTP in Germany, as examples), responsible to define nation-specific considerations, under the ITU rules (at the European level, national regulation also follows ETSI standards). These are then turned into national law by the national policy-maker (as the US Congress, or the Ministry of Public Works, Transport and Communications in Portugal, the Ministry of Industry, Tourism and Trade in Spain, the Ministry of Economics and Labour in Germany) [source]. And so, in essence, in the radio context, we have to be particularly attentive to the ITU, ETSI for Europe, and all relevant national "Regulation", in the regions and countries where we have our REVOsdr working in.

In parallel to "Regulation", there are many Non-Governmental Organizations (NGOs) that work and define "Industry Standards" or "Industry Specifications". These have permanent links to many of the referred governmental bodies. The IEEE-SA is an important example, in the radio arena, with the example of the IEEE802.11 family of "industry standards" [source], defining media access control and physical layer specifications in Wireless Local Area Networks (WLANs). These NGOs are constituted by relevant industry, research, academic players, that under the major "Regulation" umbrella, further specify common detailed operation rules. For example, IEEE802.11b specifies operation band (within the 2.4 GHz license-free band, defined by "Regulation"), number of channels and bandwidths, channel overlapping, modulation scheme, among many other technical specifications. If a radiocommunications product is specified to follow any IEEE802.11 protocol, then it needs to follow all its technical rules. The major advantage to the industry is harmonising operation of a multitude of electronic and radio systems, able to work together and at the same time (interoperability). For the end-user/buyer, the advantage is having access to an open technology market, made available from several brands, able to work together and at lower prices.

Taking on the IEEE802.11 standard example, it has further got closer to the industry, market and end-user levels: it is under the IEEE802.11 standard that the Wi-Fi Alliance [source] has developed Wi-Fi, as a "technology". And, not a coincidence, the Wi-Fi Alliance largely promoted the IEEE802.11 standard. As users, we do prefer using the term "Wi-Fi", compared to "IEEE802.11b", don't we? The Wi-Fi Alliance is a non-profit organization that promotes the "Wi-Fi technology" and certifies Wi-Fi products if they conform to certain standards of interoperability. If a radiocommunications product is officially marketed as "Wi-Fi Certified", then it is required to follow it's certification and be authorised to use the Wi-Fi logo and brand. Likewise, all Wi-Fi systems and models, from different brands, will all be able to work together in the same network, with the ultimate benefit to the end-user. What may happen, in practice also, is that a system officially specified to work under IEEE802.11b or IEEE802.11a, or "Wi-Fi compatible", is colloquially said to "work in Wi-Fi", but in fact may have no official abiding to the Wi-Fi brand certification. "IEEE802.11" and "Wi-Fi" are used interchangeably. Further, a "Wi-Fi ready" or "Wi-Fi compatible" device refers to a system ready to work in any general WLAN, and most WLANs do work following the IEEE802.11 standards. What also happens, and is definitely not right, is using the term "Wi-Fi band". But we will leave this for later.

Confused? Let's close the circle. These industrial NGO bodies, such as the IEEE-SA, take actions in technical groups within the governmental standardisation bodies. They contribute to standardisation besides also building their own important industry standards and technologies. Ultimately, their technical and market knowledge and lobbying power are fundamental tools in helping us make use of extraordinary complex technologies in our desks, hands, cars, drones, etc. And so, all legal products based on radio, following certain technologies and industrial standards (or not), certainly follow the upper level regulation, at the national and international levels. What is astonishing in such a complex world of rules, institutions, roles, interests and levels, industries and markets, is that all works together, almost harmoniously, in dealing with radio.

Let's then focus on what we want - radio use in drones! Getting the gist of the above, we can make use and communicate in the 2.4 GHz Industrial, Scientific and Medical (ISM) band, following ETSI rules for Europe, or FCC rules for the US, and not being obliged to follow any IEEE802.11 standards or Wi-Fi technology. And if we want to have our REVOsdr working in Portugal, Spain or Germany, we further need to have a look at any further restrictions at the national level, within Europe. The first thing to look at are the Radio-Frequency Allocation tables. This is important to retain is this procedure, when building and selling a radio-based technology. Does it seem simpler, now?

Other regulation for drones

This is just a small word on other Regulation fields, extremely important in flying drones. It provides perspective. It aids in further understanding how the radio link in drones is understood to be one of the major pillars in flying drones safely.

As with ITU, the International Civil Aviation Organization (ICAO) is a UN specialized agency. Its work aims at having a global safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. Again, the process is to provide global norms, as the major umbrella. Regions or countries follow these in their local civil aviation operations and regulations. The ITU, EU, the European Organization for the Safety of Air Navigation (EUROCONTROL), and also the European Space Agency (ESA) are examples of organizations that contribute to ICAO. EUROCONTROL is an intergovernmental organisation that includes both the EU member states and most other European states. Its aim is to achieve safe and seamless air traffic management across Europe. In this sector, the European Commission (EC) has generated its own standards, through the Single European Sky (SES) legislation. And, in time, joint efforts of EUROCONTROL, ESA and the EC resulted in the establishment of an additional EC organization, the European Aviation Safety Agency (EASA). To close this, important to retain is this: EUROCONTROL [source] and EASA [sources] have major rule-making roles, at the European level, directly affecting the regular and safe use of unmanned aircraft systems (we refer to these as "drones", to simplify our white papers) in Europe. In parallel and in the other side of the Atlantic, it is the Federal Aviation Administration (FAA) [source] that establishes the rules, for flying drones.

At TWEVO, we are keeping an attentive eye over radio-related drone safety processes, determined by this level of regulation. Detect And Avoid (DAA) is one example, where RADAR (RAdio Detection And Ranging) plays an important role, as a sensor providing important situational awareness data. And, independently of the sensor nature, transmitting sensor data reliably, safely and securely to the control station makes part of the whole DAA process. So, we are back to our REVOsdr radio link!

Radio in drones

The important signals

Radio signals are used for more than 3D drone control. And drone control is, itself, already a complex process. A part of such radio signals is the Control & Command (C2) link. The C2 link is fundamentally used for flight telecommand and for flight telemetry (besides a possible radio link for voice and data between Air Traffic Control and other pilots), in the up- and down-links. The other important part in the radio signals between the drone and the pilot, is the "Payload Communications Link". It concerns specific data that the drone is collecting during the flight. Most frequently, this is real-time complex sensor data, like visual or thermal images, still or moving. Most often, such data collection and transmission will be the point of using such drone for a specific purpose. Such visual data may have another function, as a fundamental tool to visually aid flight in real time, to fulfil its work mission. First Person View (FPV) is the most common tool that is made possible through the payload link, providing the pilot with the real time 'cockpit-view' image from the drone. A drone will only be truly reliable if these radio links, C2 and the data payload links, are reliable and used to their fullest, without failure.

Used bands

The most used bands for C2 and data payload links are licence-free ISM bands, Radio Amateur (ham radio) licensed bands and Short Range Devices (SRDs) bands. In civil, toy, commercial and professional drones, the most frequent band uses are the following:

- only using the 2.4 GHz ISM band, following the Wi-Fi standard, as in most toy drones
- using both the 2.4 and 5.8 GHz ISM bands, so that C2 and FPV operate in different bands, in more expensive small and light commercial drones, still following the Wi-Fi standard
- using the 2.4 GHz ISM band for radio control (one part of the C2 link), 433 MHz (ISM in Europe) or 915 MHz (ISM in the US) for telemetry (another part of C2), and either 1.3 GHz (Radio Amateur) or 5.8 GHz (ISM) bands for video transmission (including FPV), free from Wi-Fi standard rules but making use of the same bands and the same multiple access scheme (*Spread Spectrum* and *Code Division Multiple Access*)
- there are other possibilities of using these or even other bands, as the case of the 868 MHz (SRDs) band, used in some drones in Europe.

Important to retain is the general recommendation that drones for professional and more demanding use must rely on having C2 and payload links in separate bands. The point is seeking reliability in each link, lowering interference between the used bands (care is advised due to harmonics, through filtering), and increasing spectral diversity. Ultimately, it is a way to optimise and maximise spectrum use.

Spectrum use regulation

No drone-specific standards

Let us then cover the issue of spectrum use. This means dealing with the Regulation (from ITU, ETSI in the EU and FCC in the US, and then at country level) that establishes bands, their use, power levels, duty cycle, among other factors. The starting point are the Tables of Frequency Allocations [source, for Europe], [source, for the US], [source, from ITU] .

Notice that we are not dealing at the level of industry standards. The reasons are simple: there are no radio-link industry standards dedicated to radio-links in drones! And, probably, the main reason for this is that the IEEE802.11b/Wi-Fi standard, primarily directed to WLANs, has been so widely used for the drone radio links. In spite of its lack of reliability, safety and security for the use in drones, the enormous mass market of commercial and toy drones was systematically developed under Wi-Fi standard links. This has been happening in such a manner that many drone users wrongly use the expression "Wi-Fi band", when referring to the ISM 2.4 GHz band, even if the link has nothing to do with Wi-Fi or IEEE802.11.

We are then dealing with the "raw" radio spectrum use, free of any specific industry standard.

ISM

The license-free ISM applications and bands are defined at the ITU level, with region- or national-specifics. For example, uses, power level or field strength, duty cycle, modulation and many other restrictions are defined by FCC 47CFR15 and 47CFR18 regulations [source for RF devices, and source for ISM devices] in the US, or under the CEPT/ECC ERC/REC 70-03 recommendation [source for SRDs] in Europe.

One important thing to keep in mind, though, is that a radio device may work in the ISM band, while not being "ISM device". An "ISM device" is defined under ITU Regulation RRS1.15 as "equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications". But not to worry! In the end of last century, the FCC extended the ISM equipment to communications purposes, dedicating 902-928 MHz, 2400-2483.5 MHz, and 5725-5875 MHz bands to the use in unlicensed communication devices. Similarly with ETSI EN 300 328 standard and EN 301 893 standards [source and source], in Europe (Wi-Fi fits here!). And further, there are other ISM bands that coincide with bands for radiocommunications, such as "Personal Radio" (which includes Remote Control) or "Low Power Auxiliary" services, for control and/or communications purposes, in the US. Adding to this, and always paying attention to the words, using ISM bands for telemetry and control is not "telecommunications". So, at the end, many ISM bands are definitely fundamental for the use in drone links.

In the EU, the extension of the use of ISM bands to telecommunications has been made through several forms. Firstly, at the ITU level, in the "ITU Radio Regulations Footnotes for Region 1", footnotes #5.138, 5.150 and 5.280 are fundamental in determining the use of ISM bands in Europe. These determine the use of such bands for Radiocommunication services, also making clear that such "Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications". (we should always read the small print!). These ITU footnotes also include Germany and Portugal among some European countries where the 433 MHz band is an ISM band, for radiocommunications. But not Spain, for example! Not to worry - Spain has done it at their national level [source], and it is considered as "subject to local acceptance". Harmonisation working!

Another way that Europe has found to converge communication services towards the ISM bands has been to make some SRD bands coincident with ISM bands, and regulate ISM through SRD rules.

Regarding the bands most used in drones, the most known is the 2.4 GHz ISM band (worldwide ISM), but also the 433 MHz ISM band in the EU (in the US, a Radio Amateur license is required), 915 MHz in the US, or the 5.8 GHz (another worldwide ISM band).

Texas Instruments has a good summary of how US and EU ISM and SRD regulation assemble together, in the direct point of view of the radio electronics industry [source].

To retain, regarding ISM bands: there are many ISM bands, all with clear rules for their use; many of them can be useful for the use in drones, for the purpose of serving either the C2 link or the data payload link; one needs to keep a close eye to the uses that regional/national regulations allow; another thing to look at is other regulated uses in the same bands, such as SRDs; definitely, drone links can (and should!) make use of available ISM bands, with no need for further restrictions from any industry standard.

SRDs (Europe)

In Europe, the bands designated to SRDs are also license-free, with only some exceptions, following Recommendation ERC/REC 70-03 [source] and several ETSI standards [sources]. Some are also ISM bands. But most are not ISM, and do open the door to extremely important communication uses as Wireless Access Systems and Radio Local Area Networks (WAS/RLANs). But in general, SRDs refer to Radio-Frequency Identification (RFID) applications, fire, security and social alarms, vehicle radars, wireless microphones and earphones, traffic signs and signals (including control signals), remote garage door openers and car keys, barcode readers and motion detection fit. The RLANs fall into a special SRD category, described in specific Annexes (we should always read the annexes, too!).

In another point of view, take for example the 868 MHz SRD band (between 863 and 870 MHz) in Europe, dedicated to specific applications or for "Non-specific SRDs". The latter type of SRDs cover for telemetry, telecommand, alarms and data transmission (preferably used for video above 2.4 GHz). So "Non-specific SRDs" band use is also certainly relevant for drone use, adapting to the additional restrictions (power, duty cycle, etc). Moreover, also totally relevant to us, in the European context, is that the SRD applications do also include Radio-Controlled, or Remote-Controlled (RC) models (air, land or water), solely for the purpose of controlling the movement of the model. This is in another Annex in the Recommendation! And, even more, there are many ETSI standards to be checked, for specifics as applications, power levels, channels, duty cycle, Listen Before Talk (LBT), Adaptive Frequency Agility (AFA) or equivalent.

Concluding, reliable, robust and flexible radio links for drones operating in Europe must definitely look at the SRD regulation and uses. And not only because of RC models.

Personal radio service (US)

In the US, the FCC has defined and regulated several radio services, under the enormous "Personal Radio Service" group, in FCC 47CFR95 [source]. This part regulates some types of services common to some applications within the European SRDs group. Such is the case of RC systems or Citizens Band (CB).

Immediately interesting to us is, in this part 95 of the FCC rules, for the context of drone links, is the Radio Control Radio Service (RCRS). Again, with specifics, such as making it clear that the purpose must be only one-way communications, or prohibiting data transmission, for example. There are RCRS channels in the 26-28 MHz and 72 MHz frequency band made available to control and operate model aircraft (as opposed for land or water). For telecommand, any RCRS channel may be used by the operator to turn on and/or off the remote device. And for telemetry, any RCRS channel in the 26-28 MHz frequency band can be used to transmit a signal from a remote location that turns on and/or off an indicating device for the operator.

And so, though more restrictive than the RC/SRD uses in Europe, these RC-destined bands may also be useful for the C2 link in drones, making use of specific characteristics that such frequencies allow (long distance radio coverage, for example).

WAS/RLANs

As we have mentioned, in Europe, it is under the European SRD regulation ERC/REC 70-03 that WAS/RLANs are accounted for. These cover bands 2400-2483.5 MHz and 57-66 GHz, as well as for 5150-5350 MHz and 5470-5725 MHz bands, with differing rules. The 2.4 and 5 GHz RLAN regulation additionally follows the ETSI EN 300 328 [source] and ETSI EN 301 893 [source], as well as ECC/DEC/(04)08 [source]. In the US, the 2.4 GHz RLANs regulation is set in FCC 47CFR15, §15.247 and §15.249; 5 GHz RLANs are included as Unlicensed National Information Infrastructure (U-NII), in the FCC 47CFR15, subpart E rules [source], with recently revised rules [source]. The IEEE-SA has also set several IEEE802.11 standards and amendments, in the same direction. Complicated? No so. This is how we have IEEE802.11a Wi-Fi up and running, for RLANs! Around the world.

The RLAN context has such a relevant role, market-wise, that it deserves a word on the technical means that "Spectrum Sharing" implies. The demand for spectrum RLAN use has been so great, that some of these RLAN bands are also ISM bands, shared with many other radio-related systems. But that's not enough. The latter 5 GHz bands are shared with many radar systems, already running. And this is why in both sides of the Atlantic there are several operating regulations that cover such shared spectrum use. This is also why the US IEEE802.11 industry people have had a crucial role at all levels, starting at the ITU, and with implications in the US and Europe (the whole RLAN world, actually). From their origin, such RLAN systems have to protect "incumbent systems" as primarily weather radars, satellite radars, and military radars already working in common bands. The requirement for Dynamic Frequency Selection (DFS) and even Dynamic Power Control was introduced in all respective regulation (ITU, US and Europe), to avoid potential RLAN interference to such radar systems. And so, DFS includes detecting radar emissions and assuring that a RLAN does not operate on channels on which nearby radars are operating. Guessed? Right - this has direct consequences on the use of these frequencies for drone links.

The Wi-Fi Alliance has produced a good summing-up report, explaining how complex this process has been, between ITU, the FCC and the European sides [source]. Such report is also useful in explaining DFS. And, what is more, the RLAN spectrum use context is still evolving and will do so in the future [source, for the EU], [source, for the US]. All of this makes us happy, since one of REVOsdr's operation flagships is precisely spectrum sensing and agility.

But, you may ask: "Why is this important for drone links?" In such complex story of using the radio spectrum to its fullest, what has been happening in practice is that drone link applications do come up that follow the regulation for RLANs, their bands and all additional restrictions. And this is not at all new, since Wi-Fi/IEEE802.11 is being used for drones (though a drone link in not *really* a part of a *true* RLAN!). For this, the 5 GHz RLAN bands are of the utmost importance for drone links, in Europe and the US. And, for similar reasons but differently, so is the 3650–3700 MHz band, used under the IEEE 802.11y-2008 standard, also for RLANs in the US. The question some may still ask is: "Am I obliged to follow the IEEE802.11 standards to use those RLAN bands?".

Radio amateur bands

Lastly, but still important, we should not forget the Radio Amateur context, making use of an important amount of spectrum. Many of the amateur radio bands share unlicensed ISM or SRD bands, but amateur radio bands cover much more.

The original objectives of the use of Amateur Radio (known in English as "ham radio") established the exclusion of commercial and pecuniary uses, allowing for the purposes of non-commercial exchange of messages, wireless experimentation, self-training, private recreation, radiosport, contesting, and emergency communication. Their use has already then been set for authorised licensed users, called "hams", after demonstrating their knowledge. All citizens are therefore allowed to use amateur radio, after displaying knowledge and understanding of key concepts, usually by passing an exam. Such band use is not license-free. The license grants hams the privilege to operate in larger segments of the radio frequency spectrum, with a wider variety of communication techniques, and with higher power levels relative to unlicensed personal radio services. Such is why there are many accounts of licensed radio amateurs building their own drone radio links using ham radio bands, following ham regulations than benefit the control of the drone.

One example of how having a ham radio licence may be a catalyst is the case of using the 433 MHz band in the US. In Europe, it is an ISM band. But in the US, not an ISM band, a radio amateur may make use of the 420-450 MHz (70 cm) band for RC, with an available band of 30 MHz and reaching transmit powers of 1 W for model aircraft [source]. These are much higher bandwidth and power levels than any ISM allowance in the 433 MHz Europe ISM band.

The 1.3 GHz band, from 1.24 to 1.30 GHz, is another example of an amateur band available both for Europe and the US. It allows up to 50-300 mW or 10 W Equivalent Isotropically Radiated Power (EIRP) in Portugal [source] or Spain [source], or up to 10-400 W in the UK (peak envelope power level, depending on the licence) [source].

Mixing it all in

As an example of how ISM, RC model or SRD applications, Amateur Radio and industry standards all relate differently to a band, take for instance the "2.4 GHz band". One should realise that around 2.4 GHz:

- the ISM band goes from 2.4 to 2.50 GHz, in both Region 1 (where Europe is included) and Region 2 (including the US)
- the Amateur Radio 13 cm band is 2.3-2.31 GHz and 2.39-2.45GHz in the US, or 2.3-2.45 GHz in the UK, or 2.31-2.35 GHz and 2.39-2.45 GHz in other European countries, with powers reaching from 50 to 400 W (peak envelope power level, depending on the licence) in the UK, maximum EIRP of 10 W in Spain, or only usable under authorisation in Portugal
- non-specific SRDs are to work in the 2.4-2.4835 GHz band, including for RC and video data transmission in radio-controlled model

applications, reaching maximum EIRP of 10 mW in Europe

- the Bluethooth Standard (IEEE 802.15.1) and the Wi-Fi Standard (IEEE 802.11b) function in the 2.4-2.4835 GHz band, with some differences between Europe, US and Japan in the upper Wi-Fi channels, with EIRP of up to 100 mW in Europe, 1 W in the US

And so, around this “2.4 GHz band” example, we immediately see one important thing - there are numerous ways for drone links to make use of spectrum around 2.4 GHz, far beyond the Wi-Fi/IEEE802.11 “world”.

Present and future

At TWEVO, we always keep a practical view on things. Sometimes we don’t need to put enormous effort in enormously disruptive products, to sell and make our customers happy. Specially since we are reaching a market that is demanding for reliable, spectrum-agile and very low latency radio data link solutions. As of now!

This is why we see present stable regulation and firm radio services working with us for a while as real and present opportunities for making use of REVOsdr. One example is making use of the Radio Amateur context, where spectrum agility may be key in maximising available spectrum. Another example is the Unlicensed Personal Communications Service (UPCS) operating in the 1920-1930 MHz band (within FCC 47CFR15 regulation). Even such available 10 MHz band may be useful for drone communication purposes. And, again, it is another case of operation requiring channel sensing, monitoring and selection.

But at the same time we are conscious that we may contribute for future radio markets. We need to keep adapting to what the future spectrum management brings us [source, for Europe] [source, for the US]. This means not being necessarily anchored to industry standards, but accompanying them. This means providing a product that follows the required flexibility in the use of spectrum, efficiently, intelligently, allowing the sharing of frequencies and possible re-allocation/re-purposing of spectrum. This means facing new questions, too. For example: And how are we going to deal with White Space? Or what is White Space going to bring us? [source] Can we? Yes, we can!

To retain

The point of this White Paper is showing how and why different regulations and standards affect radio use in drones. In understanding this, one then understands that there are many regular use possibilities of the radio spectrum, at the global, regional or national levels. This means uses, licensing or unlicensed, bands, power levels, duty-cycles, spectrum sensing and agility, etc. We try to provide the technical background and links to where such regulatory ruling can be found, focusing in the US, Europe and some countries in Europe.

Away from the commercial and toy drone market, TWEVO’s primary focus is on data link reliability for professional drone use, with our REVOsdr data link. And for that, REVOsdr has the flexibility to change and adapt to the local, present and future regulations, always following all rules clearly defined.