RAdar para Detection and Avoidance em Veículos Aéreos Não Tripulados

RADAVANT
E6.2
PRESENT REGULATION SITUATION AND EVOLUTION II (EN)
ESTADO ATUAL DE ESTANDARDIZAÇÃO E EVOLUÇÕES II (PT)

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SUMMARY (EN):

This Deliverable builds on previous E6.1 (Oct/2018), updating, clarifying, correcting or reaffirming the Consortium's views on spectrum use, drone flight rules, and detection and avoidance regulatory matters. E6.1 and E6.2, as public documents, should be consulted jointly, accounting for relevant new regulation as of Oct/2018. It includes future and a critical insight for RADAVANT deployment, based on the most recent and matured regulation. We conclude on the spectrum bands to be used in the radar and the data link blocks. It also adds considerations on the final DAA capacity, in parallel with the envisioned targets, applications, categories, classes and scenarios.

SUMÁRIO (PT):

Este Entregável radica no anterior E6.1 (Out/2018), atualizando, clarificando, corrigindo ou reafirmando as visões do Consórcio a respeito da regulamentação no uso do espectro, regras para o voo e procedimentos de *detection and avoidance*. Os E6.1 e E6.2, como documentos públicos, devem ser consultados em conjunto, considerando a relevante nova regulamentação surgida depois de Out/2018. Inclui uma visão crítica e futura para o uso do RADAVANT, baseada na regulamentação mais recente e mais madura. Concluímos sobre que bandas serão usadas nos blocos de radar e do data link. Acrescenta considerações sobre as capacidades finais de DAA, em paralelo com os objetivos, as aplicações, categorias, classes e cenários perspetivados.

Keyword list: UAV, Drones, Radar, Regulation, Spectrum, DAA, Professional, Inspection, Surveying, Surveillance

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Table of Contents

List of Acronyms

ADS-B	Automatic Dependent Surveillance-Broadcast
AFA	Adaptive Frequency Agility
AMC	Acceptable Means of Compliance
APC	Adaptive Power Control
ASSURE	Alliance for System Safety of UAS through Research Excellence
BRLOS	Beyond Radio Line-of-Sight
BVLOS	Beyond Visual Line-of-Sight
C2	Command and Control
CE	*Conformité Européenne*
CEPT	European Conference of Postal and Telecommunications
DAA	Detect And Avoid
DFS	Dynamic Frequency Selection
DPC	Dynamic Power Control
EASA	European Aviation Safety Agency
EC	European Commission
ECC	Electronic Communications Committee
EIRP	Effective Isotropic Radiated Power
EP	European Parliament
EU	European Union
FAA	Federal Aviation Authority
FCC	Federal Communications Commission
FPV	First Person View
FTS	Flight Termination System
GM	Guidance Material
ICAO	International Civil Aviation Organization
ISM	Industrial, Scientific and Medical
ITU	International Telecommunication Union
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LBT	Listen Before Transmit
MTOM	Maximum Take-Off Mass
NAA	National Aviation Authority
RLAN	Radio Local Access Network
RLOS	Radio Line-of-Sight
SDR	Software-Defined-Radio
SORA	Specific Operation Risk Assessment
SRD	Short Range Device
STS	Standard Scenario
SWAP-C	Size, Weight And Power, and Cost
TA	Technical Annex
TCAM	Telecommunication Conformity Assessment and Market Surveillance Committee
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
U-NII	Unlicensed National Information Infrastructure
US	United States
VLOS	Visual Line-of-Sight
VO	Visual Observer
WIA	Wireless Industrial Applications
WRC	World Radiocommunication Conference

1. Scope

This deliverable primarily builds upon the previous, directly related, E6.1 deliverable, *Present Regulation Situation and Evolution I*, publicly published by the RADAVANT project in in 30-10-2018 [source]. The aim of this E6.2 deliverable is to report on any changes to the relevant regulation or past evolution perspectives, regarding the major aspects at stake: a) Spectrum use for the Radar component, b) Spectrum use for the data link component and c) Detect And Avoid (DAA) and Radar in Unmanned Aerial Vehicles (UAVs). These major aspects have been well identified and structured, based on the anchor RADAVANT system blocks, shown in E6.1 Figure 1.

This E6.2 deliverable also updates, clarifies, corrects or reaffirms the Consortium's views on these regulatory matters, compared to those stated in E6.1. Deliverables E6.1 and E6.2, as public documents, should be consulted jointly. Both share the same table of contents structure, for simpler consultation. Several directed references will be made to the content of the E6.1 deliverable, avoiding unnecessary repetition, for simplification and clarity.

2. Spectrum use for the RADAVANT Radar Component

2.1. 24GHz ISM band

As described in E6.1, the RADAVANT Radar component, is set to work in the 24 GHz ISM band (24-24.25 GHz), as an ISM equipment, namely as an Industrial equipment. This is supported by the International Telecommunication Union (ITU) Radio Regulation [ITU RR 1.15] definition, "industrial, scientific and medical (ISM) applications(of radio frequency energy): Operation of 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". Also by [ITU RR 5.150], under the provisions of ITU RR 15.13 [source], "Administrations shall take all practicable and necessary steps to ensure that radiation from equipment used for industrial, scientific and medical applications is minimal and that, outside the bands designated for use by this equipment, radiation from such equipment is at a level that does not cause harmful interference to a radiocommunication service and, in particular, to a radionavigation or any other safety service operating in accordance with the provisions of these Regulations*"*.

Accordingly, as an ISM equipment, from its base, there is no definite imposed maximum power limit to its operation, as an absolute value. RADAVANT's radar radio component, truly, is not a telecommunications but an industrial equipment.

Nevertheless, several non-automotive radar applications may be encompassed within the Non-Specific Short Range Devices (SRDs), following the ERC Recommendation 70-03, Annex 1, m) [source], in Europe. The Consortium should not rule out that the RADAVANT's radar component will in fact be required to fit respective regulation, being understood as a Non-Specific SRDs, with maximum 100 mW/20 dBm Effective Isotropic Radiated Power (EIRP). This power level and use has been again verified to still be the case of National rules in Portugal [source], Spain [source], Germany [source] and Belgium [source] (updated links). There is the exception of France [source], attributing several 24 GHz sub-bands to “Equipements non spécifiques” with differing maximum powers. Namely, 24-24.10, 24.10-24.15 and 24.15-24.25 GHz, with 100 mW, 0.1 mW and 100 mW maximum EIRP.

For the future, and as stated in E6.1, radio spectrum regulation must frequently be verified for any EU country where a target market is envisaged. In parallel, upon preparing the CE marking process, national institutions need to be checked to verify the ISM equipment vs Non-Specific SRD equipment interpretation, if higher EIRPs are desired, for the radar radio block.

As a correction to the E6.1 report, the EC 2011/829/EU decision [source] indicates a narrower 24 GHz band (24.15-24.25 GHz only), for *Non-specific SRDs* (not “for ISM purposes”, as reported in E6.1), working within such 24 GHz ISM band. EC 2006/771/EC decision, 3. of Article 3 [source], also as amended by EC 2011/829/EU decision, states that “This Decision is without prejudice to the right of Member States to allow the use of the frequency bands under less restrictive conditions than specified in the Annex to this Decision.”, and point (7) “Member States may allow, at national level, equipment to operate under more permissive conditions than specified in this Decision. However, in this case such equipment could not operate throughout the Community without restrictions and would therefore be considered as ‘Class 2’ equipment under the classification in the R&TTE Directive.”.

In the US, the use of the ISM 24 GHz band (24-24.25 GHz) is also possible, and the RADAVANT radar also fits in to the ISM equipment category. There is no explicit power limit [source, §18.305 a)] and the available bandwidth is 250 MHz, if it is interpreted as an ISM equipment. Adding to E6.1, on the other hand, if such equipment is seen as an Intentional Radiator, then power limit is severely lowered, i.e., -47.3 dBm only, compared to the EU [source, §15.249].

For this, RADAVANT will make use of the 250 MHz band, from 24 to 24.25 GHz, as an ISM System, for the main operation of its radar component, always keeping in mind any specific national regulation of the country of deployment. In respect to the future planning of any *Conformité Européenne* (CE) or Federal Communications Commission (FCC) marking, the radar radio component will be required to be a unit that is sold independently from the radar data link block. The latter is subject to other specific radio regulation.

Since no absolute maximum power limit is set to its operation, as an ISM equipment, the Consortium will conservatively keep to considering the maximum EIRP allowed for Non-Specific SRDs in the EU, 100 mW/20 dBm.

2.2. Context - Other uses and other bands

There is no relevant information to be added to the respective E6.1 section 2.2 on other uses and other bands.

3. Spectrum use for the RADAVANT data link Component

3.1. Possible Bands

The list of potential bands indicated in the respective E6.1 section 3.1 has not changed. We register slight changes to such bands list, namely in the EU 865 - 868 MHz band, for non-specific SRDs. Such band may be extended to 863-868.6 MHz or non-contiguously up to 870 MHz (as described below).

3.2. Context - the specific RADAVANT UAV use

During the project execution, the Consortium has kept attentive to any changes to the spectrum use regulation for communication purposes in the drone/UAV context, between the UAV and the control station. No particular outputs have been registered, other than a few that do not affect RADAVANT's decisions. Namely:

- the public International Civil Aviation Organization (ICAO) Position for the ITU World Radiocommunication Conference (WRC)-19, "3.4 The continuous increase in air traffic movements as well as the additional requirement for accommodating new and emerging applications such as Unmanned Aircraft Systems (UASs) is placing an increased demand on both the aviation regulatory and air traffic management mechanisms. As a result, the airspace is becoming more complex and the demand for frequency assignments (and consequential spectrum allocations) is increasing. While some of this demand can be met through improved spectral efficiency of existing radio systems in frequency bands currently allocated to aeronautical services, it is inevitable that these frequency bands may need to be increased or additional aviation spectrum allocations may need to be agreed upon to meet this demand." [source];
- WRC-2019 agreed a list of new work items to be studied by the ITU in preparation for WRC-2023, where further development of UAV Satellite Communications for Beyond Visual Line of Sight (BVLOS) operations is to be included. The agenda on the uses of IMT 5G for drones and non-safety applications had already been set [source];
- Conclude that regulatory provisions related to earth stations on board of unmanned aircraft which operate with geostationary-satellite networks in the fixed-satellite service in certain frequency bands [source], requires changes as necessary, based on the results of on-going/-completed studies [source].

Use of Spectrum in Europe

Concerning the use of spectrum for the communications between the drone and the control station, for the transmission of radar data in the RADAVANT's case, some relevant changes are to be reported in respect to E6.1.

Concerning the use of the 865-868 MHz band, for non-specific SRDs, using the whole 3 MHz band no longer allows resorting to maximum power spectral density (p.s.d.) of 6.2 dBm/100 kHz. But, on the other hand, the whole of 863-868.6 MHz (from 863-865 MHz, 865-868 MHz, 868-868.6 MHz contiguous bands, with equivalent requirements) is possible, with up to 16.1 dBm EIRP. Other sub-bands up to 870 MHz are also of possible use, though not contiguous [ERC/REC 70-03, Annex 1, bands h1.2-h1.9, source].

Following both the EC 2011/829/EU decision and Telecommunication Conformity Assessment and Market Surveillance Committee (TCAM) [source], the RADAVANT data link will be able to use the 863-865 MHz/865-868 MHz band, as a Class 1 equipment (sub-classes 66 and 67), with up to 16.1 dBm EIRP and as long as the system implements Listen Before Transmit (LBT) + Adaptive Frequency Agility (AFA). It may also function under other sub-classes, for the same bands, but with limited duty cycles.

In respect to 5 GHz Wideband Data Transmission Systems/Radio Local Access Networks (RLANs) bands, no changes are to be registered, in respect to E6.1. The Consortium's keeps it decision that RADAVANT shall not primarily operate in the Wideband Data Transmission Systems/RLANs 5150-5250 MHz, 5250-5350 MHz and 5470-5725 MHz bands (in Europe), under the current rules.

On the the unlicensed 5725 - 5875 MHz band, as a *Tracking, Tracing and Data Acquisition* SRD, this band is being prepared for the use as Wireless Industrial Applications (WIAs), allowing a maximum of 400 mW (26 dBm) EIRP [ERC/REC 70-03, Annex 2, band d, source], according to harmonised standard EN 303 258 (under development). Nevertheless, its use requires Adaptive Power Control (APC), Dynamic Frequency Selection (DFS) and DAA (in the radio spectrum sense), besides a registration and/or notification, leading to a Class 2 radio equipment. For this complexity, such WIA use of the 5725 - 5875 MHz band will not be a present objective.

Finally, taking from the conclusions set forth in E6.1, the updated readily available bands for the use in the radar data link in Europe are the following:

- the 863-865 MHz/865-868 MHz band, as a *Non-Specific SRD*, with up to 16.1 dBm EIRP, with LBT + AFA [ERC/REC 70-03, Annex 1, bands h1.2-h1.9, source];
- the unlicensed 2400 - 2483.5 MHz band, as a *Non-Specific SRD*, maximum 10 mW (10 dBm) EIRP [ERC/REC 70-03, Annex 1, band i, source], according to harmonised standard EN 300 440;
- the unlicensed 2400 - 2483.5 MHz band, as a *Wideband Data Transmission System* SRD, maximum 100 mW (20 dBm) EIRP (for wideband modulations other than FHSS, the maximum e.i.r.p. density is limited to 10mW/MHz), Adequate spectrum sharing mechanism (e.g. LBT and DAA) shall be implemented, [ERC/REC 70-03, Annex 3, band b, source], according to harmonised standard ETSI EN 300 328;
- the unlicensed 5725 - 5875 MHz band, as a *Non-Specific SRD*, maximum 25 mW (14 dBm) EIRP [ERC/REC 70-03, Annex 1, band j, source], according to harmonised standard EN 300 440;

As before, RADAVANT's data link must be prepared for a higher level of security and resilience, compared to other communication services sharing such same unlicensed bands.

Use of Spectrum in the US

As in E6.1, we look at the US context, to broaden the target towards the US market. For the Unlicensed National Information Infrastructure (U-NII)/RLANs [FCC 47CFR15, subpart E rules] [source], the above decision on the 5150 - 5250 MHz, 5250 - 5350 MHz and 5470 - 5725 MHz bands is kept unchanged. For such band uses, RADAVANT's data link must be prepared to deploy Dynamic Frequency Selection (DFS) and even Dynamic Power Control (DPC), in the US.

As in Europe, the 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz unlicensed bands are of direct use for RADAVANT's radar data link, for *non-application-specific radio applications*, *intentional radiator* [FCC 47CFR15, subpart C rules, §15.247] [source]. Unlike that stated in E6.1, the 5725 - 5850 MHz band, for U-NII/RLANs, is not of primary interest for RADAVANT's data link, for its implementation complexity, as in Europe.

Other UAV-Specific Implications, related to Spectrum

Following E6.1, the ECC Report 268 still remains an updated present crucial reference, bridging between the European Parliament (EP), the European Commission (EC), the European Aviation Safety Agency (EASA), the Federal Aviation Authority (FAA), and also ICAO, confirming RADAVANT project planning, as well as Twevo's plan towards the UAV/drone market.

The spectrum issues are very closely intertwined with UAV flying regulations, concerning professional and non-professional drone use, categorisation of operations as 'Open' or 'Specific', the base 'Open' subcategories A0 and A1 for non-professional use (mostly using the unlicensed shared 2400-2483.5 MHz and 5725-5875 MHz bands), subcategories A2 and A3 for professional use and licensed and specific UAV use bands, as well as emphasising the need for the use of dedicated, licensed spectrum bands, for professional UAV use, evolving to a safer market.

The ECC Report 268 report stresses the need for resilience in relation to interference or intentional sabotage, in particular for the Command and Control (C2) radio link. Such radio systems must incorporate security measures including solid encryption, with implications on the bandwidth and channelling of these C2 links. Though the RADAVANT radar data link block does not fall into the C2 category, but more as a sort of payload, it is the Consortium's belief that the transmission of RADAVANT's radar data should require similar robustness, as a fundamental tool within the drone DAA processes.

4. Relevant DAA Regulation and Definitions

The DAA Regulation base analysis published in E6.1 remains valid. The main EU regulatory background, as in E6.1, is also described by EASA [source]. Some important new add-ons are to be hereby reported on, from either the EU and the US, in the matter of use and control of UAVs, including DAA and operational conditions.

As before, the project mainly accounts for EASA's harmonising outputs, joining contributions from ITU, ICAO, EC/EP, CEPT, EASA, FCC, FAA, Joint Authorities for Rulemaking on Unmanned Systems (JARUS) and NAAs. All contribute to outputs relevant to the RADAVANT project. At this later stage, the project is more focused on the EU EC/EP-level regulation, as well as EASA's most recent outputs, regarding operational conditions converging to RADAVANT's radar uses.

4.1. Important Definitions

As in deliverable E6.1, the most important definitions are kept, resulting from several of the above mentioned institutions. Namely on *Beyond Radio Line-of-Sight* (BRLOS), BVLOS, DAA, *Hazard*, *Mitigation*, *Non-segregated Airspace*, *Radio Line-of-Sight* (RLOS), *Segregated airspace* and Visual Line-Of-Sight (VLOS).

In relation to the RADAVANT project and its applications, it is important to be aware of the sort of risks involved in the planned UAV operations. These have been structured in E6.1 and are based on the same principle: in order to include such flight operations in the non-segregated airspace, most likely and in most inspection and surveying operations, the RADAVANT radar will contribute to mitigating such risks. As in E6.1, these are [based on ICAO, source]:

- *conflicting traffic*: considered in the Technical Annex (TA) as *mobile traffic*, airborne or terrestrial, in the vicinity of the UAV. In inspections, this can be the case of other UAVs, planes (though not probable to be of large size), helicopters, trains, cars or trucks. There are very practical real-life situations where such traffic is probable, e.g., the inspection of a road viaduct and the close passage of a large truck, or the inspection of a rail-road and the unexpected approach of a train;
- *terrain and obstacles*: considered in the TA as *fixed obstacles*, e.g., large walls, electric power lines, metal tower masts, tubes;
- *hazardous meteorological conditions*: though not considered in the TA, and although most can be predicted, there is effectively a risk of sudden storms, ice, turbulence, strong wind, heavy rain;
- *ground operations*: considered in the TA as *terrestrial mobile traffic* or *terrestrial fixed obstacles* that may conflict with the take-off and landing;
- *other airborne hazards, including wake turbulence, wind shear, birds or volcanic ash*: some may be out of the scope of RADAVANT, but other are very pertinent, to be considered as *mobile or terrestrial traffic*, e.g., birds or moving cattle.

4.2. EC/EP + EASA Regulation

There have been several relevant EU regulation and EASA proposed standards for certification, as well as various EASA published *opinions*, after the publication of our E6.1 Deliverable. Some of these have crucial consequences in the context of the use of a radar, such as RADAVANT, for collision avoidance in the use of professional UAVs for inspection, supervision, surveying or surveillance operations. These are:

- 11-06-2019: the EC published common European rules on drones, Commission Delegated Regulation (EU) 2019/945 [source] & Commission Implementing Regulation (EU) 2019/947 [source], as a result from previous EASA Opinion No. 01/2018 [source]. Regulation (EU) 2019/947 enters into force on December 31, 2020;
- 16-10-2019: EASA published a document issuing Acceptable Means of Compliance and Guidance Material to the Commission Implementing Regulation (EU) No 2019/947. With the publication, EASA is supporting UAV operators and Member States in harmoniously complying with the adopted EU regulation, for the 'Open' and 'Specific' categories, for operation-centric, proportionate, risk-and performance-based regulatory framework, to ensure a high and uniform level of safety for UASs, with a first issue of Acceptable Means of Compliance (AMC) and Guidance Material (GM). [source] and [source];
- 11-11-2019: EASA published the Opinion No. 05/2019 "Standard scenarios for UAS (Unmanned Aircraft Systems) operations in the 'specific' category" which is proposing an amendment to the European regulation (Implementing Act) to add two low risk Standard Scenarios (STSs), STS-01 and STS-02. Under these scenarios, drone operators will be allowed to just send a declaration to the respective authority instead of applying and waiting for an authorisation. One of these scenarios is a BVLOS, with operations with the UAV at not more than 2 km from the remote pilot, if Visual Observers (VOs) are used, at a maximum height of 120 m, over controlled ground areas in sparsely populated

environments, using UAVs with Maximum Take-Off Masses (MTOMs) of up to 25 kg. In case of no VOs are present, the control BVLOS distance is reduced to a maximum of 1 km, of the UAV flies a pre-programmed flight, allowing the UAV/remote pilot to scan the airspace themselves. Additionally, launch (e.g. take-off) and the recovery (e.g. landing) are also required to be performed in VLOS, for security. Attention is drawn to defining VLOS conditions, with VLOS range varying depending on the physical characteristics of the UAV and on weather conditions, up to a distance such that the remote pilot can clearly distinguish the UAV in the sky, as well as for mitigating the risks of BVLOS operation, including geo-caging, the need for Flight Termination System (FTS), Contingency and emergency procedures, among other relevant conditions [source];

- 13-03-2020: EASA published Opinion No. 01/2020, to create and harmonise the necessary conditions for manned and unmanned aircraft to operate safely in the U-space airspace, preventing collisions between aircraft and to mitigating air and ground risks. In this regulation proposal, the practical demands related to BVLOS operations within the U-space are made clear, possibly requiring airspace restrictions such as segregated airspace, as well as frequently implying the consultation among several stakeholders concerned. Similarly, the document states that the current lack of DAA and U-space services technologies and maturity still cannot allow the necessary integration, implying that U-space participants need to be cooperative, sharing real-time information regarding their actual position in the U-space airspace. Opinion No. 01/2020 calls for new concepts (such as tactical separation, and why not, airborne radar) and DAA systems to evolve and mature further, including standardisation wise, to be later included or considered in regulation on U-space. In many cases, BVLOS operations in the Member States are possible in segregated airspace, where the UAS operations take place, [source];
- 16-04-2020: EASA published the Notice of Proposed Amendment (NPA-2020-07) to clarify the conditions under which UAS BVLOS operations over a populated area or an assembly of people can be authorised in the ‘Specific’ category, amending AMC & GM to Regulation (EU) 2019/947, defining the ground risk classes for two operational scenarios: BVLOS operations over a populated area and BVLOS operations over an assembly of people (in public discussion until 15-05-2020). The NPA-2020-07 also contributes to defining what ‘sparsely populated areas’ are, of relevance for many of the operational scenarios envisaged for RADAVANT radar [source];
- 13-05-2020: the EC published Commission Implementing Regulation (EU) 2020/639 of 12 May 2020 amending Implementing Regulation (EU) 2019/947 as regards standard scenarios for operations executed in VLOS or BVLOS, in common European rules, Commission Delegated Regulation (EU) 2019/945, adopting Opinion No. 05/2019 [source];
- 27-04-2020: the EC published Commission Delegated Regulation (EU) 2020/1058, amending Delegated Regulation (EU) 2019/945 on the introduction of two new unmanned aircraft systems classes (C5 and C6, for the STS-01 and STS-02 scenarios, respectively), with different sets of requirements addressing different risks (for low risk operation and for which the UAS operator is allowed to submit a declaration based on the standard scenario listed in Appendix 1 to the Annex to Commission Implementing Regulation (EU) 2019/947, not requiring standard aeronautical compliance procedures) [source];
- 20-07-2020: EASA published the Special Condition for Light UAS proposal (under public consultation until 30-09-2020), applicable to unmanned aircraft under 600 Kg, operated in the ‘Specific’ (medium and high risk) or ‘Certified’ categories in accordance with regulation (EU) 2019/947, including in BVLOS over populated areas and over assemblies of people, with . It makes part of a “wider initiative to ensure drones can be operated safely and acceptably, particularly in areas which are densely occupied by people and moving or static objects”. It does not does not define the use of certain equipment that might be required

for specific operations, such a Transponder, Automatic Dependent Surveillance-Broadcast (ADS-B), Flight Recorders, radar, etc [source].

4.3. A short view on FAA Regulation

Though the RADAVANT project primarily has an European scope, the Consortium keeps attention towards the US market, as already done in respect to the radar block.

Since 2016, FAA Part 107 rules apply, for small, under 25 kg UAVs, but no specific VLOS or BVLOS scenarios are dealt with. Concerning drone operation, the FAA has in 31-12-2019 published a Notice of Proposed Rulemaking, on the Remote Identification of UASs [source]. The document has been under very active public discussion until the 02-03-2020, with heavy criticism on the need for a permanent internet network connection. It goes beyond such matter, namely in respect to BVLOS, arguing that remote identification is prerequisite for feasibility of large scale BVLOS operations. The root for such proposed regulation is the need for remote identification, preferably in real-time, being aware of the limitations of current electronic surveillance technologies, like transponders and ADS-B. According to the document, these had "been considered as potential solutions for the remote identification of UAS but were determined to be unsuitable due to the lack of infrastructure for these technologies at lower altitudes and potential saturation of available radio frequency spectrum". In fact, such proposed regulation prohibits the use of ADS-B Out, as well as transponders, for UAS operations under 14 CFR part 107 (and part 91) unless otherwise authorized by the FAA.

4.4. Relation with RADAVANT: Operation Categories and Scenarios

As described in deliverable E6.1, in relation to RADAVANT, within the 'Open' category, the primary project's scope will be the professional use under operational subcategories A2 and A3. Such is also because of the most probable UAV weight, close to or above 4 kg (under 25 kg), and the type of deployment scenarios that we are envisaging. Most probably, the UASs where RADAVANT will be installed will fit into UAS C2 to C4 classes, and with flights far from people or close to uninvolved people. For this, the EASA Special Condition for Light UAS proposal does not totally fit out context. Concerning the new C5 and C6 classes, that arise from C3 class with specific operation changes (e.g., concerning maximum flight height and power) and added requirements, the RADAVANT project should include such classes for possible installations. The STS-02 'Specific' category low risk BVLOS STSs, published in EASA Opinion No. 05/2019, implemented by Regulation (EU) 2019/947, with or without VOs, is very well directed towards the scenarios initially envisaged by the RADAVANT project, in respect to BVLOS operation. STS-02 refers to controlled ground areas that shall be entirely located in a sparsely populated area, i.e., where many inspection, surveying or surveillance actions do occur.

Again, in the context of RADAVANT and as in E6.1, the project keeps a critical view on the following practical deployment scenario, still probably contributing to a new STS (post-project, if the occasion is made possible):

- In the inspection of a bridge, the UAV operation and the position of the pilot is mostly VLOS, mostly with short distances;

- But there are two very frequent situations where the UAV is not visually followed: a) the pilot is on the bridge deck and the UAV goes under the bridge deck, or b) pilot and UAV are separated by a pillar, all at very short distances of 10 m;
- Such are BVLOS and BRLOS situations, for which "Minimum equipment requirements to support BVLOS operations increase significantly as the range and complexity of such operations increase, as does the cost involved in ensuring the robustness of the C2 link. The ability to detect conflicting traffic or obstacles and take appropriate action to avoid them is essential." [ICAO, source];
- As in 30-12-2018, with E6.1, we conclude that even in the short distances, such BVLOS scenario has not been directly found mentioned or described among the several regulatory bodies. Such possible new standard scenario is where RADAVANT radar, as well as the effective use of First Person View (FPV), is to be absolutely essential, as in the case of long distances.
- The recently defined STS-02 scenario may be considered to include such short-distance BVLOS conditions.

4.5. RADAVANT and its role for DAA

As made clear in the RADAVANT TA, RADAVANT radar will complement other control and safety signals and services for (a) *obstacle avoidance*, in respect to large obstacles around the UAV, and (b) *collision avoidance*, in respect to moving traffic, aerial or terrestrial, around the UAV. In the foreseen context of inspection, supervision, surveying or surveillance, RADAVANT will provide the remote pilot with real-time information on fixed obstacles, e.g., large walls, power cables, metallic posts, and on moving obstacles, e.g., planes, helicopters, trains, cars, trucks, other UAVs, diggers, cranes or even birds.

For this, the issue of remote identification, ADS-B or transponder use, are out of the scope of this project. These, anyhow, are seen as some of the cooperative, complementary means that, together with RADAVANT radar, on the whole contribute to safety and airworthiness. Anyhow, on the one hand, as is planned to happen in the US, ADS-B and transponders may not even be installed in UAVs. And on the other hand, most of the practical obstacles and moving traffic likely present in the UAV RADAVANT context (listed above), in inspection, surveying or surveillance operations, will not involve any of such cooperative signals or services whatsoever.

Taking on the respective E6.1 section 4.3 contributions, we hereby update and reaffirm them, following the most recent regulation outputs.

The RADAVANT Consortium should follow the above category/class guidelines, primarily from EASA. Under the wider scope of the RADAVANT project and for the envisaged markets, its deployment should be directed to the 'Open' A2 and A3 subcategories. It should be extended to the 'Specific' and/or 'Certified' categories, due to the nature of the flights, including BVLOS in inspections and surveying, following the risk-centred view. As planned, again, RADAVANT project has kept a close look at such developments and future radar developments. Post-project, Twevo will follow this approach, for the future development of the radar.

The EU rulemaking for UAV flights under the 'Specific' and/or 'Certified' categories has further evolved since Oct/2018, being better defined and structured, specifically regarding BVLOS conditions and reference scenarios. In the US context, the project has kept following the way that waivers are being submitted and accepted (as well as rejected), keeping track of the BVLOS tendencies for the future [source], or from the FCC's-backed Alliance for System Safety of UAS through Research Excellence (ASSURE) report [source].

For either the EU or US contexts, the specific inspection, surveying or surveillance deployment scenarios envisioned for the use of RADAVANT radar, with frequent BVLOS, short UAV-remote pilot distances, low speed and low MTOM, still lack proper definition. Recent EASA efforts, with the creation of STS-05 and STS-06 scenarios, head in such direction.

Based on such background and on the article "A Review on Collision Avoidance Systems for Unmanned Aerial Vehicles" [source], the project has kept its way to further fit its contribution for the future in DAA for UAVs:

- "a collision avoidance system is generally organized into three fundamental functions: the sensing function, the detection function and the resolution function.". RADAVANT will fit into the sensing and detection, aiding in the resolution to be taken by the pilot;
- Radar fulfils its role, regarding range, azimuth, elevation, day and night operation (or lit and in the dark operation), bad weather, for specific deployment scenarios. RADAVANT will be capable of fulfilling these, in the context of the inspection, surveying or surveillance deployment scenarios;
- RADAVANT will be a non-cooperative passive DAA process, complementary to possibly future UAV transponder and ADS-B cooperative, or other Electronic Conspicuity, processes. Such perspective of complementary processes for DAA will, undoubtedly, be the solution for safe and cost-efficient UAV drone missions (for VLOS and BVLOS);
- Radar is still generally pointed as a heavy, large and expensive solution. RADAVANT is an excellent opportunity to counteract such wrong view (with SWAP-C, *size weight and power, and cost* benefits). Our close competitors are also very much aware of this.

5. Conclusions

This E6.2 report builds on previous E6.1, published on the 31-10-2018. It updates, corrects and reaffirms several of its content, since relevant regulation has been published, in the meantime. As with E6.1, we have kept the extensive look at the several Regulations and Regulatory Bodies concerned, guiding RADAVANT's decisions on its radar, data link and combined DAA functions. The major conclusions are the following:

- RADAVANT's radar block will work in the 24 GHz ISM band, for the EU, US and other markets, possibly as an ISM/Industrial equipment. For CE or FCC marking, in the future, such radar block is to be marked, marketed and commercialised separately from the other RADAVANT blocks. Since such ISM band is only 250 MHz wide, the Consortium has provided a solution to follow the TA main specifications, namely, concerning the spatio-temporal resolution. RADAVANT's radar implementation is flexible and ready for any regulation changes in this band, if required;
- RADAVANT's data link block will primarily function in the 865 MHz (EU)/915 MHz (US) (shared, unlicensed), 2.4 GHz (shared, unlicensed, also ISM) and 5.8 GHz (shared, unlicensed, also ISM), including operation capabilities that will guarantee the reliability and safety required for professional use. RADAVANT's data link and any future implementation is ready for regulation changes in these bands, if required;
- The RADAVANT Consortium has kept following the evolution of decisions on these spectrum matters. The flexibility of Twevo's Software-Defined-Radio (SDR) technology will be of the utmost importance, in adjusting to such regulation and needs, if required;
- The RADAVANT radar should be applied in the 'Open' A2 and A3 subcategories, C2 to C4 classes, with flights far from people or close to uninvolved people. Also in the 'Specific' category, C5 and C6 classes, under the STS-01 and STS-2 scenarios. It is ready to be further extended to the 'Specific' and/or 'Certified' categories, when new regulation arises;
- After the near conclusion of the RADAVANT project, Twevo will keep track of future STSs, mainly with the aim of helping create regulatory space for inspection, supervision, surveying or surveillance operations, with frequent BVLOS, short UAV-remote pilot distances, low speed and low MTOM. Twevo will be ready to contribute to these STSs, if adequate.