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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Surveillance Radar equipment for helicopter application operating in the 76 GHz to 79 GHz frequency range

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Executive summary

The helicopter's unique hover and vertical take-off/landing capabilities make it ideally suited for transport in difficult access areas, take-off and land in confined areas (Figure 1) and perform hoisting operations (Figure 2). In these frequently encountered and demanding mission elements the pilot faces an increase in workload when scanning for obstacles and monitoring helicopter state. Especially in degraded visual conditions and unknown or confined areas, there is an imminent danger of collision with all kinds of obstacles, which continues to be among the top causes of civil helicopter accidents.

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Figure 1: Operations in confined areas

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Figure 2: Hoisting operations close to obstacles

The present document describes the heliborne application of 76 GHz to 79 GHz radar technology, in a near environment obstacle warning system. The application here used the benefit that automotive radar made the technology available but the technical parameters and sensor architecture for helicopter are different. The intended function of this system is to detect and inform the flight crew of obstacles in the direct vicinity of the helicopter environment. The surround coverage of the radar system will aid the crew in the obstacle detection task while manoeuvring at low airspeeds typically close to the ground. The system will help and improve the probability of detection of obstacles thereby increasing situational awareness and flight safety. It will reduce pilot's workload and can save time in critical flight phases, which is important especially for safety of life services.

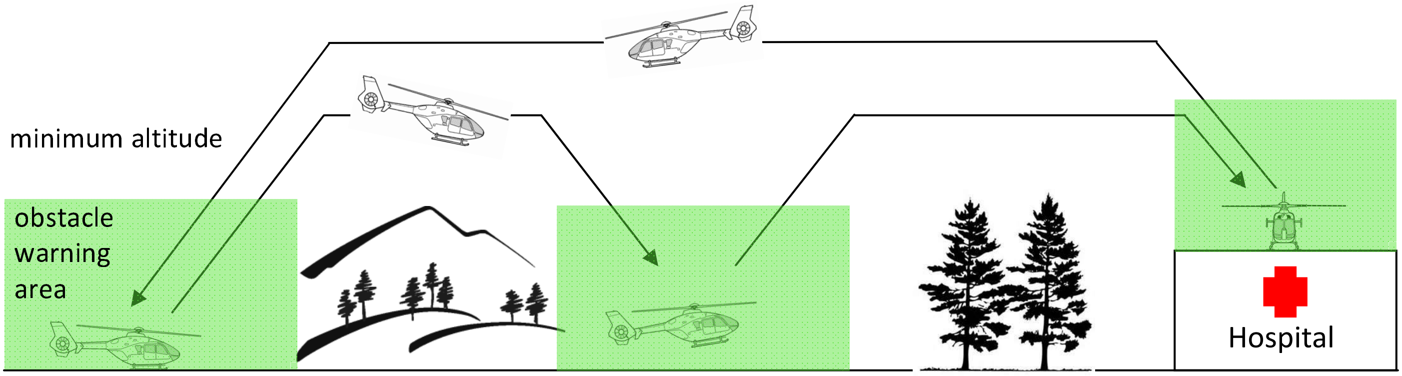

Figure 3: Typical operational profile for helicopter emergency medical service

Figure 3 shows a typical HEMS (helicopter emergency medical service) mission. The helicopter takes off from the helipad/airfield using the obstacle warning system until it rises out of the obstacle scene. After arriving at the accident site, the helicopter descends to the landing zone and picks up the person injured. During landing, hover and take-off, the obstacle warning system inform the flight crew of obstacles in the direct vicinity of the helicopter environment. The helicopter flies in cruise altitude to the hospital. During landing and take-off at the hospital, the flight crew again is informed of obstacle by the obstacle warning system. The system will be switched off during cruise flight back to the helicopters air base but will be active during the landing phase at the air base.

Minimum flying altitudes and off-field landing are regulated for each state.

Examples of regulation:

- Germany:
  - Landing outside of airfield (off-field landing) is only allowed after permission from authority. Exceptions are e.g. emergency landing and helicopter emergency medical service.
  - Minimum altitude is 300 m (1 000 feet) above residential area, production plants, gatherings and accident sites above the highest obstacle in an area of 600 m. For all other areas it is 150 m (500 feet) above ground and water.

    For cross-country flights, a minimum altitude of 600 m (2 000 feet) is applicable.
- France:
  - Landing outside of airfield (off-field landing) is only allowed after permission from authority. Exceptions are e.g. emergency landing and helicopter emergency medical service.
  - Minimum altitude is 300 m (1 000 feet) above residential area, production plants, gatherings and accident sites. For all other areas it is 150 m (500 feet) above ground and water.

The Size, Weight and Power (SWaP) characteristics of 76 GHz to 79 GHz sensors make them ideally suited for use on smaller H/C types typically being used by civil operators. Due to the short wavelength and high bandwidth the precise measurement (in range and doppler) enables an accurate and reliable detection of those obstacles posing a threat to safe helicopter operations. The fact, that the automotive radar technology is proven and readily available makes it the only affordable sensor technology for a short-term market entry for this novel kind of application.

The aim is to enable the usage of already existing technology available e.g. in the automotive area for helicopter applications.

In the introduction of ERC Recommendation 70-03 [i.10], the following is stated:

"The CEPT has considered the use of SRD devices on board aircraft and it has concluded that, from the CEPT regulatory perspective, such use is allowed under the same conditions provided in the relevant Annex of Recommendation 70-03. For aviation safety aspects, the CEPT is not the right body to address this matter which remains the responsibility of aircraft manufacturers or aircraft owners who should consult with the relevant national or regional aviation bodies before the installation and use of such devices on board aircraft."

Introduction

The present document has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

1 Scope

The present document describes the radar based surveillance applications in the 76 GHz to 79 GHz frequency range for a helicopter obstacle warning system. The 76 GHz RTTT Standard EN 301 091 [i.5] and the 77 GHz to 81 GHz RTTT Standard EN 302 264 [i.8], could be used as a baseline to defines the technical characteristics and test methods for this new radar equipment operating in the 76 GHz to 79 GHz range.

It includes in particular:

- Market information.
- Technical information (including expected sharing and compatibility issues).
- Regulatory issues.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] EASA: "Annual Safety Review 2010", 2011.

[i.2] ITU Radio Regulations (Edition of 2012).

[i.3] ERC Report 25: "The European table of frequency allocations and utilisations in the frequency range 9 kHz to 3000 GHz".

[i.4] CEPT/ERC/Recommendation 74-01: "Unwanted Emissions in the Spurious Domain".

[i.5] ETSI EN 301 091 (Parts 1 and 2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Radar equipment operating in the 76 GHz to 77 GHz range".

[i.6] Commission Implementing Decision 2011/829/EU of 8 December 2011 amending Decision 2006/771/EC on harmonization of the radio spectrum for use by short-range devices.

[i.7] Commission Decision 2004/545/EC of 8 July 2004 on the harmonization of radio spectrum in the 79 GHz range for the use of automotive short-range radar equipment in the Community.

[i.8] ETSI EN 302 264 (Parts 1 and 2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Short Range Radar equipment operating in the 77 GHz to 81 GHz band".

[i.9] ECC/DEC/(04)03 of 19 March 2004 on the frequency band 77 - 81 GHz to be designated for the use of Automotive Short Range Radars.

[i.10] CEPT/ERC REC 70-03: "Relating to the Use of Short Range Devices (SRD)".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

e.i.r.p.	equivalent isotropically radiated power
EASA	European Aviation Safety Agency
EESS	Earth Exploration Satellite Service
EUT	Equipment Under Test
FMCW	Frequency Modulated Continuous Wave
FPGA	Field Programmable Gated Array
H/C	Helicopter
HEMS	Helicopter Emergency Medical Services
ISM	Industrial, Scientific and Medical
LPR	Level Probing Radar
MIMO	Multiple Input Multiple Output
MMIC	Monolithic Microwave Integrated Circuit
PDCF	Power Density Correction Factor
RBW	Resolution Bandwidth
RCS	Radar Cross Section
RF	Radio Frequency
RTTT	Road Transport and Traffic Telematics
SRD	Short Range Devices
SRR	Short Range Radar
TLPR	Tank Level Probing Radar
UWB	Ultra-Wideband
VLBI	Very Long Baseline Interferometry

4 Comments on the System Reference Document

No comments raised by ETSI members.

5 Presentation of the system or technology

The proposed system concept consists of multiple radar sensors distributed around the helicopter fuselage to detect obstacles entering a certain protective volume around the helicopter. The surround coverage of this Heliborne Obstacle Warning system will aid the crew in the obstacle detection task while manoeuvring at low airspeeds typically close to the ground. The system reduces the risk of collision with objects by an early detection of obstacles and will therefore improve safety for aircrew, passengers and persons on the ground. The system is developed to perform adequately even in degraded visual conditions in which the pilot's ability to visually detect obstacles might otherwise be severely compromised.

Depending on the required coverage, the field-of-view of the individual sensors, the installation location and the number of sensors to be integrated might vary.

The obstacle warning function can be decomposed in the following subfunctions:

- The Detection Subfunction for the perception of the environment as used by automotive radar technology operating in the range 76 GHz to 79 GHz.

- After subsequent processing the obstacle information can be presented to the flight crew.

In an example implementation the sensors are integrated below the main rotor head in a distributed manner such as to cover a larger horizontal field-of-view (Figures 4 and 5). In this orientation the Heliborne Obstacle Warning System is aimed at providing obstacle warning for obstacles that enter the main rotor plane. Typical use cases therefore involve hovering flight as well as manoeuvring at low airspeeds.

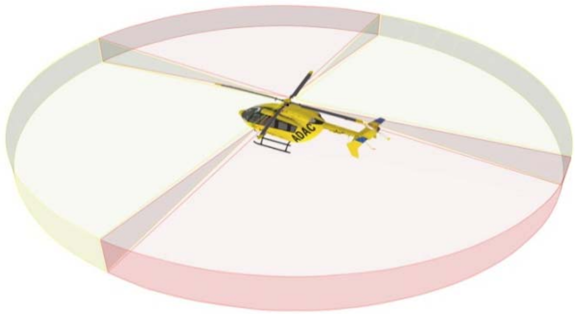

Figure 4: E.g. sensor coverage (360° configuration)

Figure 5: Landing in confined area

For a small helicopter type as depicted above, typically 4 sensors need to be integrated to cover the full 360° horizontal field-of-view.

As described earlier, the operational benefit of this system is in the initial or final phases of flight in which the helicopter manoeuvres in ground vicinity at low airspeeds. It is in those flight phases in which there is an increased risk of collision with all kinds of obstacles. The system will be used in environment with obstacles in the vicinity of the helicopter, only. It will be switched off if the helicopter leaves this environment. This will be defined in the flight manual. The effective detection range of the sensor system is prescribed by the velocity at which the helicopter approaches the environment as well as the minimum warning time needed for the pilot to assess the situation and initiate evasive manoeuvres. When considering only hovering and low-airspeed manoeuvring phases of flight (e.g. landing, hoisting operations, taxiing), the required detection range is limited to 250 m which is similar to detection range of automotive radars for which the 77 GHz technology has been developed. The required transmit power as described in the 76 GHz to 77 GHz regulation (refer to Recommendation 70-03 Annex 5, Frequency Band c [i.10]) is sufficient.

However, in the 77 GHz to 81 GHz regulation (refer to Recommendation 70-03 [i.10], Annex 5, Frequency Band e) the obstacle warning sensor will exceed the transmit power as it is not sufficient to detect all relevant obstacles within the required 250 m detection range.

The performance of the system is defined by the probability of detection within the detection range of those obstacles that typically pose a threat to helicopter operations in hover or at low airspeeds. Frequently encountered obstacles of particular danger are for instance suspended wires (e.g. overhead power lines, guy wires), poles, fences, trees, buildings, etc.

The Heliborne Obstacle Warning System is designed to inform the flight crew about the presence and location of obstacles. In a first implementation the system is an aid to the pilot with the pilot being responsible to visually verify the obstacle indications given by the system. The output of the system has to be interpreted as an indication and will improve the probability of detection of obstacles by the pilot.

The certification of the obstacle warning system will require a certification which is under the responsibility of respective certification authorities (e.g. EASA) and is not discussed in the present document.

Table 1: Technical parameters of the obstacle warning system

Technical Parameter of the obstacle warning system (example)	
Frequency Range	76 GHz to 79 GHz
Range of Sensor	250 m
Peak Power (e.i.r.p.)	40 dBm/50 MHz
Mean power spectral density (e.i.r.p.)	32 dBm/MHz
Bandwidth for 76 GHz to 77 GHz	800 MHz
Bandwith for 76 GHz to 79 GHz	100 MHz with typical center frequencies of 76,05 GHz, 77,5 GHz and 78,95 GHz
Operational cycle of transmitter	50 ms, within this time the transmitter is active for 6 to 14 ms

Table 2: Technical parameters of the scenario

Technical Parameter of the scenario	
Field of View coverage	Full coverage
Typical minimum RCS of the objects detected	-10 dB/m^2
Typical number of helicopter operating in the scene	One helicopter, for specific scenarios like large scale operations of Emergency Medical Services or Police Services, several helicopter can be in the scene

The following table gives an overview of the different mission types that will have a direct benefit of the proposed system in various mission elements. It is obvious, that the proposed Heliborne Obstacle Warning System can offer valuable support to the flight crew in a wide range of missions in a wide range of operating environments. Not only does the flight crew benefit from the increase in flight safety, also passengers, victims to be rescued and people on the ground have a direct benefit of safer helicopter operations.