Country report on the use of drones in construction-related activities

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1 OVERVIEW (AT NATIONAL LEVEL)

1.1 Regulations (Standard Operating Conditions)

Which regulations apply depends on the type of use and the size and weight of the drone. In 2017, the national regulations (so-called drone regulations) governing the operation of Unmanned Aircraft Systttems (UAS) were published.

However, new EU regulations, DVO (EU) 2019/947 and DVO (EU) 2019/945, apply to the operation of UAS from 31.12.2020. The following regulations currently apply in all EU member states:

The operation of a UAS is divided into three operating categories: "open", "specific" and "certified".

In the "open" operating category, for example, a maximum flight altitude of 120 metres above ground applies and constant visual contact with the UAS must be ensured. Furthermore, the minimum age for remote pilots is 16 years and the maximum permitted take-off mass is less than 25 kilograms. No dangerous goods may be transported or other objects dropped.

If one of the specified requirements for the "open" operating category is not met, the UAS operation automatically falls into the "specific" or "certified" category. Further approvals must be obtained for this (see chapter 3 "Training").

With the EU regulation came the obligation to register operators. An operator (e.g. a company, group or individual entrepreneur) can own several drones and also employ several remote pilots. After receiving an allocation number, it must be attached to each UAS (e.g. as a small aluminium plate).

In addition to these EU-wide regulations, there are also national laws that must be observed. This means that a German drone pilot must still inquire about national regulations in other EU countries and vice versa. National regulations restrict, for example, UAS operations near airports or critical infrastructure. The regulations for UAS operations are laid down in Section 5a of the German Air Traffic Regulations (LuftVO). It lists, among other things, geographical areas for unmanned aerial vehicles that are mandatory for every remote pilot.

These are for example:

- o Minimum 1.5 km lateral separation from the boundary of aerodromes that are not airports.

- o Minimum 1000 metres lateral separation from the boundary of airports. In addition, all directions of approach and departure must be taken into account by

extending the runways by 5 km in each direction with a width of 1000 metres from the runway centrelines.

o Residential properties may be overflown at 100 metres to 120 metres under certain conditions (alternatively: consent of the owner).

o 100 metre separation to limit sensitive areas. These include: Industrial facilities, correctional facilities, facilities for the correction of psychiatric disorders, military facilities and organisations, facilities for the central generation and distribution of energy, facilities in which activities requiring a permit under Protection Level 4 of the Biological Substances Ordinance are carried out, properties of federal and state constitutional bodies, or supreme and higher federal and state authorities, properties of diplomatic and consultative representations, as well as international organisations as defined by international law, properties of police and other security authorities and hospitals.

o Minimum distance of 10 metres to federal roads, waterways and railway facilities. Additional application of the 1:1 rule (lateral distance of the aircraft from the mode of transport ≥ height of the aircraft above ground). Additional crossing of federal waterways permitted under certain circumstances.

o Nature conservation areas (except national parks!) may be flown over at 100 metres to 120 metres under certain conditions.

o Outdoor swimming pools, bathing beaches and similar facilities may only be overflown outside operating or bathing hours.

o 100 metres distance to accident sites, operational sites of authorities and organisations with security tasks (BOS) and armed forces.

o Air traffic control clearance required for drone operations in a control zone.

1.2 Strategic plan for the development of RPAs/drones in the country. Priorities

In 2020, the German government presented an action plan on drones entitled "Unmanned Aerial Systems and Innovative Aviation Concepts". With the action plan, the Federal Government is pursuing three goals to advance UAS applications in Germany. The three milestones, which will serve as guidelines on the way to the regular operation of UAS are as follows:

1. Germany wants to become a lead market and establish high safety standards.

2. Germany wants to bring automated and connected flying into practice.

3. The protection of personal data, privacy and the environment must be ensured.

Overview of key measures of the action plan and selected examples:

- New framework for the operation of drones
    - Development of a digital platform for unmanned aviation. In concrete terms, the aim is to enable networking and data exchange between the air traffic participants involved (cooperative air traffic) and to bundle all relevant information for drone operations on a central platform.
- Focused detection and countermeasures
    - Development of a roadmap for drone detection near airports.
- Strengthening Germany as a location for innovation
    - Research funding for drones and air taxis will be continued and expanded.
    - Establishment of specific temporary test fields, also cross-border with interested neighbouring countries.
- Creating more social acceptance of drones
    - Information campaign informing about the benefits and dangers of drone applications and highlighting measures to protect citizens.
    - Research projects investigating what noise and light emissions drones cause, what disruptive effects exist and how these can be reduced.
- Air taxis for passenger transport and as a possible emergency ambulance in air rescue services
    - The Federal Government cooperates in the development of regulations for air taxi certification at the European Union Aviation Safety Agency EASA.
    - A legal framework is being created to combine mobility services. The goal is a multimedia transport chain that includes air taxis. Focal points: Airfields should be interoperable for different air taxis; where possible, existing airfields should be able to be shared by air taxis.

1.3   Government agencies with jurisdiction over RPAs

In the federal structure of the Federal Republic of Germany, the aviation authorities of the federal states are responsible for all administrative acts in connection with the ascent and operation of drones for civil use. No new aviation safety authorities were established for this responsibility, but the tasks were transferred to existing authorities.

These are the aviation authorities of the 16 federal states:

- o BW: State Aviation Authority Baden-Württemberg: Regional Council Stuttgart

- o BY: State Aviation Authority Bavaria: Government of Upper Bavaria (Aviation Authority of Southern Bavaria) and Government of Middle Franconia (Aviation Office of Northern Bavaria)

- o B: State Aviation Authority Berlin: Senate Department for the Environment, Transport and Climate Protection and Joint Higher Aviation Authority Berlin-Brandenburg (LuBB)

- o BB: State Aviation Authority Brandenburg: Joint Higher Aviation Authority Berlin-Brandenburg (LuBB)

- o HB: State Aviation Authority Bremen: Senate for Science and Ports

- o HH: State Aviation Authority Hamburg: Authority for Economic Affairs and Innovation - Aviation Supervision

- o HE: State Aviation Authority Hesse: Regional Council Darmstadt - Planning & Traffic and Regional Council Kassel - Planning & Traffic

- o MV: State Aviation Authority Mecklenburg-Vorpommern: Ministry of Economy, Infrastructure, Tourism and Labour

- o NI: State Aviation Authority Lower Saxony: State Authority for Road Construction and Transport

- o NRW: State Aviation Authority North Rhine-Westphalia: Düsseldorf District Government - Transport Division and Münster District Government - Traffic Division

- o RP: State Aviation Authority Rhineland-Palatinate: State Enterprise Mobility Rhineland-Palatinate

- o SL: State Aviation Authority Saarland: Ministry for the Environment, Climate, Mobility, Agriculture and Consumer Protection

- o SN: State Aviation Authority Saxony: Saxony Regional Directorate - Air Transport and Inland Navigation

- o SA: State Aviation Authority Saxony-Anhalt: Saxony-Anhalt State Administration Office - Economy - Transport

- o SH: State Aviation Authority Schleswig-Holstein: State Office for Road Construction and Transport Schleswig Holstein

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o TH: State Aviation Authority Thuringia: Thuringian State Administration Office - Air Traffic

In addition to the state aviation authorities, the Federal Aviation Authority (Luftfahrtbundesamt, LBA) and the German Air Traffic Control (Deutsche Flugsicherung, DFS) are also aviation authorities in Germany.

1.4   RPA operator qualification requirements / Pilot certifications needed

The new EU regulations standardise the requirements for drone pilots. From now on, there are two licences: the EU Certificate of Competence A1/A3 (colloquially also called "small EU drone licence") and the EU Remote Pilot Certificate A2 (colloquially also called "large EU drone licence").

Which certificate you need depends on how you want to use your drone and which drone classification it belongs to. It is important to know that drones are divided into five risk classes: C0, C1, C2, C3 and C4. These risk classes subdivide drones according to their risk, such as weight, design and safety functions. Furthermore, there are three application scenarios of drones ("open", "specific" and "certified"), with "open" being the most common main category.

The main category "open" is again divided into three subclasses:

o A1: Here, flight is also possible in the vicinity of people. Flights over outdoor crowds and uninvolved persons are prohibited.

o A2: Here, flights are only permitted at a safe distance from uninvolved persons with a distance of at least 30 metres. However, the distance may be reduced to up to 5 metres when the drone is in slow mode.

o A3: When flying the drones, no uninvolved persons may be present in the entire flight area. In addition, a distance of at least 150 metres must be maintained from residential, commercial, industrial or recreational areas.

Generally speaking, since 31 December 2020, all drone pilots must hold an EU drone licence. There are only a few exceptions, which are listed below:

o Drones with a C0 class

o Self-built drones with less than 250 grams ascent weight and a maximum speed below 19 m/s

o Until 31.12.2022: old devices with less than 500 grams ascent weight

o From 01.01.2023: old devices with less than 250 grams ascent weight

1.5 Key figures (nº of registered operators like corporations, SMEs…; registered aircrafts; …)

Number of drones in Germany

In Germany, there are 430,700 drones in circulation. The number of privately used drones exceeds the number of commercially used drones by a factor of 8. However, the market for private drones seems to be saturated, while the commercial use of drones is becoming increasingly popular: Since 2019, the number of commercially operated drones has more than doubled (+138%), while the number of privately used drones has declined (-14.5%).

- o 385,500 drones in private use
    - o Toy drones up to a value of €300 account for just about a third of this
    - o The other two-thirds are so-called prosumer drones, which are equipped with a small camera and are used by their users for holiday photos, among other things
- o 45,200 drones in commercial use

Drone companies in Germany

- o Nearly 400 companies with a main focus on drone technology/unmanned aviation
- o Characterised by a strong start-up culture
- o Small workforce of around seventeen employees on average (2019: 12 employees)
- o Low age of the companies of around six years (2019: 3 years)
- o Average annual turnover of companies specialising in drones: €670,000 (2019: €330,000)

Market demand

- o Estimated at a total of €840 million (2019: €574 million)
    - o €738 million (2019: €404 million) attributable to the commercial drone market
    - o €102 million (2019: €169 million) attributable to the private drone market
- o Hardware market: €206 million (2019: €241 million)

- o Software market: €33 million (2019: €37 million); includes, for example, software for flight planning, flight execution and data processing
  - o 98% commercial and only 2% private
- o Service market is the largest segment with €600 million (2019: €296 million)
  - o 100% attributable to the commercial drone market; includes, for example, all services provided with drones by all companies in all industry sectors

Market forecast

- o Number of drones is expected to increase to around 450,000 by 2025
- o By 2025, one in three drones will be used commercially (an increase to 132,000, while private drones will decrease)
- o Drone market to grow from €840 million to over €1.6 billion by 2025 (equivalent to an annual average growth rate of 14.5%)

2 INDUSTRY OVERVIEW

2.1 Focus → Related activities linked to RPAs

There are many areas of application for drones in the construction industry. What makes their application particularly attractive is the fact that drones can be used throughout the entire life cycle of a building, i.e. not only during the construction phase, but also in the preceding planning and design phase as well as during the use phase of a building.

Examples of key applications for drones in the construction industry include:

- o Building inspection
- o Construction site safety
- o Visualisations (e.g. 3D models)
- o Surveying work
- o Monitoring of construction progress
- o Communication
- o Transport of components and tools

2.2 Developments

With regard to drone applications in the construction sector, rapid advances in technical development can be observed. Simply flying over and observing from above is a thing of the past. In addition to pinpoint surveying with an accuracy of 2-3 centimetres at a flight altitude of 100-120 metres above the ground and images in real time, there are many other developments worth mentioning.

Drones can fly autonomously using a GPS module that indicates where to stop and take a photo if necessary. With the help of such POIs (points of interest), all neuralgic points relevant to maintenance can be flown to, inspected and documented.

Drones that provide thermal images (infrared thermography) are now also available – prototypes have also been developed that use X-rays to inspect their surroundings. The recording of a thermographic model has several advantages. The smallest defects and flaws that cannot be seen with the human eye can be precisely depicted, such as millimetre cracks in the building's surface. Moreover, infrared thermography can be used to record the condition of materials, for example. The presence of thermal bridges and moisture can be detected and conclusions can be drawn about the energy efficiency of a building. In addition, thermal cameras can easily reach areas that are difficult or

impossible to reach for human inspections during "visual monitoring", which means optical surveys, observations and aerial photography.

Especially for Building Information Modelling (BIM), the data transmitted by drones will make indispensable contributions in the future.

2.3   Sector statistics

According to a survey (as of 2021) by the Institute for Construction Management at the University of Duisburg-Essen, only 30 percent of respondents from the construction industry use drones for professional purposes on the construction site (i.e. 70 percent are non-users). Of the 30 percent who actually use drones, they are applied for the following tasks:

- o   32% for inspection, especially recordings of the building stock and structural inspection
- o   29% for construction documentation
- o   16% for measuring/surveying purposes
- o   13% for advertising purposes
- o   10% for the creation of 3D models

2.4   Sector challenges → Technology adoption and gaps (Drone adoption)

In addition to the acceptance of drones and emerging technologies in the traditional construction industry, which still has room for improvement, especially among small and medium-sized enterprises, the lack of digitalisation in some areas represents a major challenge.

Despite the fact that many business owners understand and recognise the benefits that new technologies can bring, it is still a rarity for smaller construction companies to invest in the introduction of a new technology for their business.

While drones are still mostly controlled manually, the future lies in automated flying drones. One challenge is the connection of drones with artificial intelligence. The integration of AI (deep learning) requires additional research and development work, for example to enable the collaborative use of the artificial neural network for monitoring the entire construction process.

Furthermore, data protection concerns and safety aspects are further obstacles on the way to a widespread use of drones in the construction sector.

2.5 Key takeaways from the survey (from companies & professionals)

Takeaway #1: At present, know-how regarding drone applications is only available to a limited extent.

- 15% said they do not currently use drones at all.
- 59% answered that they use drones only rarely, another 23% use them occasionally.
- Only 27% of respondents reported drone expertise within the company.
- 73% said they use external service providers when it comes to drone applications.

Takeaway #2: Companies are willing to implement various application possibilities in their company in the near future.

- The most frequently mentioned potential applications included surveying work, photography and/or video, equipment tracking and thermal imaging

Takeaway #3: The development of standardised training courses should be promoted.

- The most mentioned solution to tackle the skills shortage regarding drone technology is the implementation of standardised training courses that match the different jobs in the sector (65%).

3 TRAINING

3.1 Specific training and licensing for RPAS pilots

EU Certificate of Competence A1/A3 ("Small EU Drone Licence")

For the EU Certificate of Competence A1/A3 you have to complete an online training and pass an online exam. The exam consists of 40 multiple choice questions from the following 9 subject areas:

- o Flight safety

- o Airspace restrictions

- o Air law

- o Human performance and its limitations

- o Operating procedures

- o General knowledge of UAS

- o Privacy and data protection

- o Insurance of drones

- o Aviation security

To pass, 75% of the questions must be answered correctly. The exam can be repeated several times if you fail. The small drone licence is valid for five years and can be extended by taking a repeat examination or a refresher course.

In Germany, the Luftfahrtbundesamt (LBA) offers both the online training and the exam. There is a fee of 25 euros. Click here to go to the website of the Federal Aviation Authority: https://lba-openuav.de

EU Remote Pilot Certificate A2 ("Large EU Drone Licence")

The large licence builds on the small one, i.e. it requires passing the online exam at the LBA described above.

The theoretical exam for the Remote Pilot Certificate A2 consists of 30 multiple choice questions from 3 subject areas:

- o Meteorology

    Weather influences on the operation of a UAS (wind, temperature, air density), visibility, obtaining weather forecasts.

- o UAS flight performance

  UAS categories and their operating ranges, centre of gravity position, mass and balance, securing payload, batteries.

- o Technical and operational mitigation of risks on the ground

  Technical and operational measures, functions in slow flight mode, 1:1 rule, estimation of distance to people.

The examination is offered by centres designated by the LBA (see chapter 3.2).

The EU Remote Pilot Certificate A2 exam also requires at least 75 per cent of the questions to be answered correctly in order to pass. The large drone licence is valid for five years. The certificate can also be extended by taking a retest or a refresher course.

Each examination centre charges its own fee for the training and the examination acceptance – usually a low to mid three-digit amount. In addition, a fee of 30 euros must be paid to the LBA for the issue of the certificate.

Specific Category

The "specific" category includes all common operations that are not covered by the "open" category. It describes drone flights with an increased risk to other persons or to air traffic.

In the "specific" category, it is not permitted to fly over crowds of people, transport people or transport dangerous goods with a drone. The "certified" category was created for these special cases.

If a person wants to fly with a drone in the "specific" category, this is only permitted after a prior risk assessment. In addition, approval by the competent authority is required. The competent authority is always the authority in the country in which the drone operator is registered. Registration is mandatory in the "specific" category.

Approval by the authority can be obtained in three ways:

- o Approval as part of membership in a model aircraft association

- o Declaration of compliance with standard scenarios

- o Operating permit: Will be granted after review of a risk assessment according to the SORA procedure by the competent authority

The exact requirements that will apply in the "specific" category in the future will only be determined by the ancillary provisions that are defined with the standard scenarios or issued in the operating licences.

As a drone pilot in the "specific" category, a whole range of knowledge is required. It is essential to be familiar with the following topics:

- o Application of operating procedures
- o Dealing with aeronautical communications
- o Mastery of flight routes and automation
- o Leadership, teamwork and self-management
- o Problem solving and decision making
- o Situation awareness
- o Managing workload
- o Coordination and handover
- o Explaining procedures for cross-border deployment
- o Compulsory registration

Beyond this, however, the authorities may demand further competencies that one must master as a drone pilot.

3.2 Description and comparison of the current training offer

While the EU Certificate of Competence A1/A3 is obtained online through the Federal Aviation Authority (LBA) by passing a multiple-choice examination, there are several providers who offer training courses, including practical training, for the EU Remote Pilot Certificate. Some of these are testing centres designated by the LBA, where the examination can also be officially conducted and a certificate acquired.

The following list provides an overview of the best-known training options throughout Germany:

Training provider	Info
AERIAL ACADEMY	Online courses for the EU Remote Pilot Certificate A2.
Airclip Service GmbH & Co. KG*	Online and face-to-face courses for the EU Remote Pilot Certificate A2 as well as industry-specific special training courses. *Testing centre appointed by the Federal German Aviation Authority (LBA)*

BORMATEC*	Online and face-to-face courses for the EU Remote Pilot Certificate A2 as well as further practical training and workshops on drone use for deer rescue. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
CiS GmbH*	In-house training courses for EU Remote Pilot Certificate A2 as well as UAS training including flight practice and UAS user training for flight evaluation. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Copter-Expert GmbH*	Online and face-to-face courses for the EU Remote Pilot Certificate A2 as well as training courses for firefighters and security organisations. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Copteruni GmbH*	Online courses for the EU Remote Pilot Certificate A2. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Delta-Drone	Only on-site training for the EU Remote Pilot Certificate A2 as well as drone beginner courses and training for drone photography.
Drohnenflugschule24*	EU Remote Pilot Certificate A2 online via live webinar or as classroom or in-house training, as well as other specialised courses and flying lessons. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Drone Class	Online courses for the EU Remote Pilot Certificate A2.
droneLIONS Academy	Online and face-to-face courses for the EU Remote Pilot Certificate A2 as well as industry-specific special training courses.

Dronesperhour GmbH (DPH)*	EU Remote Pilot Certificate A2 online for self-study or as a digital seminar via videoconference as well as practical flight training on site. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Kopter-Profi GmbH*	EU Remote Pilot Certificate A2 online or in presence as well as further theoretical seminars and practical trainings around the operation of drones. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Kopterzentrale GmbH*	Training courses for the EU Remote Pilot Certificate A2 as well as drone seminars for company groups and as individual training, both in presence and as an online event. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
Pro Fly Center	Online and on-site courses for the EU Remote Pilot Certificate A2 as well as courses for flying in the specific category.
RKM - RotorKonzept Multikoptermanufaktur GmbH*	Training courses for the EU Remote Pilot Certificate A2 online or in presence as well as application-oriented courses for advanced drone pilots, e.g. on infrastructure inspections, roof surveys or surveying with UAS. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
RolaWind GmbH*	Online and on-site courses for the EU Remote Pilot Certificate A2 as well as courses for flying in the specific category. In addition, there is a large number of courses for the special category. Provider with additional workshops for the industry-specific use of drones (e.g. photogrammetry). *Testing centre appointed by the Federal German Aviation Authority (LBA)*

Seabirds.de GmbH*	Classroom training (one day) on the EU Remote Pilot Certificate A2. Additional practical courses can be booked on request. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
TB Copters GmbH*	Online learning material and exercise manual for practical training as well as online examination for the EU Remote Pilot Certificate A2. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
UAVDACH-Services*	Training for the EU Remote Pilot Certificate A2 and additional practical training courses in the handling of UAS. *Testing centre appointed by the Federal German Aviation Authority (LBA)*
U-ROB GmbH*	Choice of online or classroom training for the EU Remote Pilot Certificate A2. Provider of further training such as flight training as well as special training on drone applications, e.g. in industry and trade at 11 locations in Germany. *Testing centre appointed by the Federal German Aviation Authority (LBA)*

3.3 Key takeaways from the survey (from learners/trainees)

Takeaway #1: The vast majority of learners have little to no familiarity with drone technology.

- o 56% of respondents said they had never used a drone and knew little about how they work.

- o 36% said they have never used a drone but understand how they work.

Takeaway #2: The majority is not aware of the most in-demand jobs or relevant emerging roles in the construction industry.

- o Only 36% answered yes to the question about awareness of relevant ermerging roles and most in-demand jobs.

Takeaway #3: The degree of digitalisation in companies and during training must be strongly increased.

- o 35% of respondents cited limited exposure to the technology already during training as the reason for the lack of drone training courses.
- o 29% of the respondents complained about the low adoption of new technologies in the companies.
- o 18% of respondents complain about insufficient facilities or equipment for practical training.

Takeaway #4: There are several areas of application for drone technology in which the respondents have shown great interest.

- o Almost half of the respondents (46%) were interested in photography and/or video.
- o 30% were interested in the use of drones in connection with quality control and assurance.
- o 14% indicated surveying as their drone application of choice.
- o 10% were interested in the use of drones in connection with preconstruction and site planning.

CONCLUSIONS

The use of drones on construction sites is not yet a widespread phenomenon. While small and medium-sized companies generally work little or hardly at all with drones due to the digitalisation backlog, it is already no longer a rarity for large industrial companies in the construction sector.

It is no longer a question of "if" drones will become part of the standard repertoire for every construction project, but only a question of "when". It is therefore all the more important that construction companies deal with the megatrend of digitalisation in general and with drone technology in particular.

Against the backdrop of the shortage of skilled workers, this is all the more important, as the use of drones on the one hand speeds up and simplifies work processes where previously many employees needed a lot of time, and on the other hand also contributes to increasing the attractiveness of the construction sector among young people or potential trainees. In conclusion, the winners of drone technology will be those companies that have developed and implemented their own drone and digitalisation strategy at an early stage.

While there are nationwide training programmes for the two EU drone operator's licences, there are no construction-specific programmes for the diverse uses of drones on the construction site. There is an urgent need for action here, especially with regard to the use of drones in education and training in the construction sector.

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