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The DJI Dock 2 is a "Drone in a Box" to Enhance the Unmanned Guard Solution – Scientific Research with the Cooperation of Duplitec Ltd.

The DJI Dock 2 "drone in a box" is an enhanced version of the previous Dock 1 solution, where a more sophisticated, agile, mobile, lightweight and efficient product has been introduced to improve and meet the needs of reliable, fully autonomous drone operations even at an extended range. The latest advances in technology will enable the organisation, planning and execution of fully automated flight operations with drones, even beyond visual range. There are many missions and tasks that were previously dangerous to perform with human resources because it was too risky or did not provide an efficient and satisfactory solution for the control, guarding, protection or continuous surveillance of sites important for the operation of public bodies, sectors of the national economy or for guaranteeing the safety of the population. Now these problems can be adequately addressed with the DJI Dock 2 and its accessories, as it can be used for drone-powered patrols and guarded tours around protected areas.

Keywords: *DJI Dock 2, full automatic drone flight, technical capabilities and specificities, mission planning and execution, operational conditions, legislation*

1. Introduction

Over the past decade, natural disasters have become more frequent and severe, prompting communities to develop new, innovative technological solutions to reduce the impact of disasters [9].

Unmanned Aircraft System (UAS) technology is advanced and versatile, and they are already successfully used in many areas of aviation. However, their full integration into general aviation is still an open issue as they face a number of safety and regulatory challenges [2].

The interest in UAVs has increased significantly in recent years. The main reason is that UAVs can perform difficult or dangerous tasks with high mobility, safe operation and low cost [6].

UAVs are now increasingly integrated into disaster management and humanitarian aid [7]. Among its many benefits, it is important to note that the presence of UAVs can eliminate citizen's concerns from a public protection approach and ultimately support business growth [8]. However, their effective use in mass disasters is still in its infancy.

The protection of critical systems and facilities, including critical infrastructures and other key assets, is mandatory and requires newly developed automated or semi-automated solutions to enhance the security of these institutions. The big challenge is sometimes the harsh and bare environment where human intervention is not possible or dangerous, so security issues need to be addressed by unmanned (robotic) solutions where these conditions can be managed in an appropriate and safe way [3].

Unmanned aerial systems are an important part of these solutions, where UAS(s) equipped with different payloads, mostly with different types of sensors and cameras, can provide significant solutions to address these security issues. In general, the industrial, military and key infrastructures and the protected areas are extensive and, therefore, the coverage in terms of shape, form and time is challenging, especially for fully automated systems. Drones in themselves offer significant solutions for detection, surveillance, monitoring and many other tasks, but operations need to be aligned with existing legislation, especially for beyond visual line of sight (BVLOS) or special (licensed) operations. Remote or unattended operations is a new area in the industry with its own specific challenges and requirements. It is well known that in engineering development, engineers are always striving to achieve higher performance, coverage, connectivity, reliability and ultimate accessibility of a technology, but these also require complex coordination tasks [1].

It is important to note that the security challenges associated with drones, particularly the issue of targeting explosives or explosive devices, have been highlighted for more than a decade. "The quadcopter is therefore a technical tool that, if properly designed, can be used to support our own troops. It can assist in countering improvised explosive devices, but it must be remembered that in the wrong hands it can become a weapon of great effectiveness" [11]. The world's largest parcel delivery company has also been testing and using unmanned aerial vehicles to move parcels and goods for some time. The devices would be used mostly for moving parcels between warehouses and between airports and remote depots. Again, the main motivation for deployment is to reduce costs and minimise transport time [11]. The risk is therefore real, and in the case of critical infrastructure, it is a major risk factor [12].

In the event of a nuclear or radiological emergency, the rapid availability of reliable data is crucial for government decisions that can affect thousands of people and have significant social, economic and environmental impacts. There are two main approaches to investigate a radiological situation: one is to equip early intervention teams with transportable radiation detectors and send them to the affected areas, and the other is to measure remotely using unmanned vehicles carrying radiological detection systems to measure relevant radiological parameters. The latter approach is increasingly preferred in order to protect public health [5].

At critical infrastructure sites such as ports, refineries, the highest security standards apply, but the execution of deliberate attacks, including the transport of goods containing explosives or other dangerous materials, spying on personnel, suppliers, visitors and operations, perimeter surveillance, movement of security personnel, can occur at any time and in any place [3].

DJI has developed the latest version of the "drone in the nest" solution, which allows you to manage the flight plan and execution of the flight without the presence of a remote control, and all flight paths are fully automated. This helps security agencies to save human resources, protect human lives in hazardous environments where appropriate, simplify policies, procedures and ultimately move everything to a more automated version where

information is detected, monitored, processed and distributed in real-time to the disposition authorities or agents.

Duplitec Ltd., as the main distributor of drones and unmanned aerial systems in Hungary, provides the DJI Dock 2 solution as a new capability for security and safety services to solve these security challenges and build a standardised technology, where drones do patrols – like sentry drones – to provide technology-based security systems where only one technical director (remote pilot) is enough in the loop to monitor ongoing situations (situational awareness) and intervene when the situation dictates, where everything can be based on local networks [4].

2. Discussion

The DJI Dock 2 is an automated, unattended operating platform with a highly integrated design, including an ultra-wide-angle camera, wind speed sensor, rain gauge, communication antennas, RTK (real-time kinematic positioning) module and Uninterrupted Power Supply (UPS). It has a fast charging module that charges the battery from 10% to 90% in 25 minutes. The operating range is up to 10 km. Total docking weight is 34 kg (excluding aircraft weight), input voltage is AC 100-240 V, 50/60 Hz, IP55 protection class, and the maximum operating altitude is 4000 m.

DJI's dock 2 to accommodate Matrice 3D/3TD type drone versions is equipped with multiple redundancy flight control systems, six directional sensors and positioning systems, a powerful multi-camera payload and a new First Person View (FPV) camera night vision system that provides Return to Home and obstacle detection. Total weight: 1410 g (without baggage), maximum take-off weight: 1610 g, maximum flight time: 50 minutes, maximum operating altitude: 4000 m, image transmission solution: O3 Enterprise, video transmission range Federal Communications Commission (FCC): 15 km, European Conformity (CE): 8 km, State Radio Regulation of China (SRRC): 8 km, "MIC" video transmission (MIC): 8 km, wide angle camera: 1/1.32 inch, complementary metal-oxide-semiconductor (CMOS); 48 MP, telephoto camera: 1/2 inch CMOS; 12MP; 56x hybrid zoom, thermal imaging 640 x 512 @ 30 fps (Figure 1).

Figure 1.
DJI Dock 2 and Matrice 3D/3DT [14]

As setup and installation progresses, the selected site must meet the requirements and complete the DJI Dock 2 Site Survey Checklist. Environmental conditions and requirements must also be met, including operating temperature, altitude of the installation site, weather conditions, interference from strong electromagnetic waves such as radar stations, mobile communications base stations, and equipment that may interfere with the drone. The DJI Dock 2 does not have a Wi-Fi connection, LAN establishment is provided via a fast Ethernet, therefore, an outdoor LTE/WI-FI available Ethernet port is required. When using a direct Ethernet cable connection from the IT room to the dock, the maximum distance between the connection points should not exceed 80 m. Gigabit networking is recommended, and the upstream bandwidth should be more than 10 Mbps, but it is recommended to be over 40 Mbps. Bandwidth is critical and connectivity is important in understanding how much data you will be pushing through a connection, especially if you are in a backup application and cannot capture video every time the mission – in progress – is running. Due to these challenges, and depending on user's infocommunication options – Starlink, a cellular outdoor LTE/Wi-Fi modem, or hardline fiber – it is mandatory to have backup solutions in the dock when the primary link goes down, especially for a fully remote system [14].

Important factors in drone technologies are regulatory considerations, which sometimes put aircraft manufacturers under tough conditions that they must meet at any time and in any environment in order to ensure the reliable integrity of aircraft in national airspace. The most exciting operation is the BVLOS, where different types of operations are acceptable at prescribed and predetermined altitudes around critical infrastructure – where regulation would be more permissive in terms of altitudes than at other non-critical locations – and predetermined ranges must also be regulated. A very important issue is operations over people, where other safety requirements are introduced to ensure safer operation of aircraft, such as the use of third-party accessories such as drone parachute rescue and flight-interruption systems that allow pilots to fly without difficulty in overpopulated areas or beyond visual range. Notwithstanding this, BVLOS operations – which are, however, based on reliable Unmanned Traffic Management/Unmanned SPACE (UTM/U-SPACE) environments that are not used for air traffic control in most cases – must be aborted by remote pilots (remote controllers) at any time when a warning, alert message is sent, which is distributed via the UTM system.

As the system can be installed and operated as a stand-alone system, the designated site can be located away from the controlled area. Self-defence solutions such as protective fencing, third-party security cameras and other surveillance systems will be required, which can provide the unit with some force protection capability to protect against intruders or unauthorised persons. Consequently, the unit may be installed on the roof or in other locations where access by unauthorised persons is severely restricted or where there are other guarding and monitoring devices in the environment that can be used to detect any unauthorised access immediately.

The configuration process involves updating the firmware of the dock, the aircraft and the remote control to the latest version, checking the status of the micro SD card of the aircraft and formatting the memory card to exFAT format. Before connecting the aircraft to the DJI Dock, it should be connected to the remote for a flight test to ensure safety. By default, the network configuration is automatically assigned an IP address, so no special configuration is

required. If you want to use a static IP, you will need to configure it separately. To ensure the safety of the docking flight test, the remote control can be used to manually take control of the aircraft during flight after connecting to the aircraft as a B controller. After configuring the dock and the drone, the next step is cloud management. The first action is to create a flight plan using the Flight Route Library icon (Figure 2). In this menu, you can enter the flight route editor, set the route parameters and plan the flight route. After the route design, we can create a new task by clicking on the Task plan library icon. In this menu, we can link the created flight plan to a planned task and choose the selected dock, which will be assigned to execute the planned task based on the pre-planned flight paths. You can also set the timer for the plan and the Return to Home (RTH) altitude relative to the dock, and finally click OK to complete the new flight plan. Through the cloud management, you can access the maintenance interface, where you can view live and storage data of the dock and its associated drone, as well as debugging.

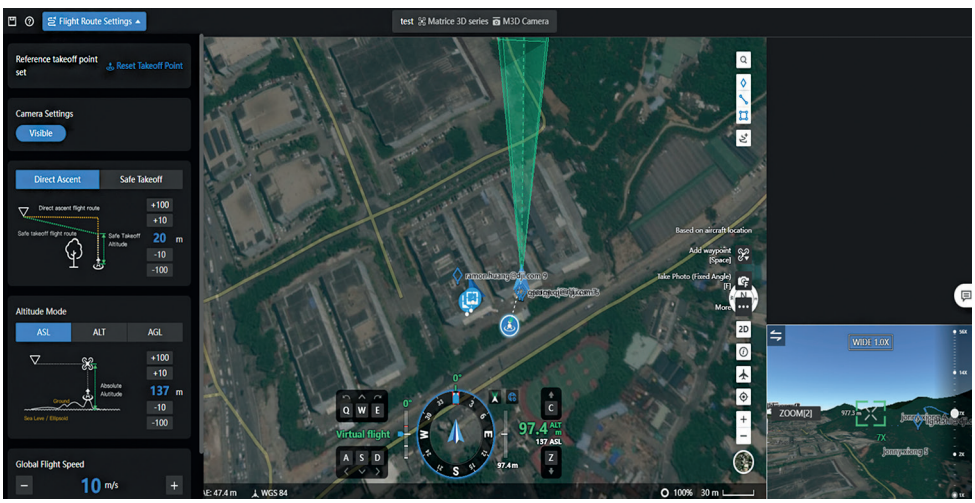

Figure 2.
Flight path library [based on the authors' own editing]

DJI docking station is rugged, reliable and designed to work around the clock, day or night, rain or shine, you can schedule missions, create and edit flight paths and manage the data you collect. Before a mission, the aircraft uses vision sensors to detect the surrounding environment and quickly determine if there are strong Global Navigation Satellite Systems (GNSS) signals in the area. This new, vision-based evaluation significantly speeds up site selection, reducing the time required from five hours to twelve minutes or less [15].

The FlighHub2 is a turnkey solution suitable for autonomous drone operations, but there is also the option of a "controller B" solution. Access to a central interface by multiple users, cloud-based system. Device status monitoring (abnormal operation, environmental parameters, states) is available (Figure 3).

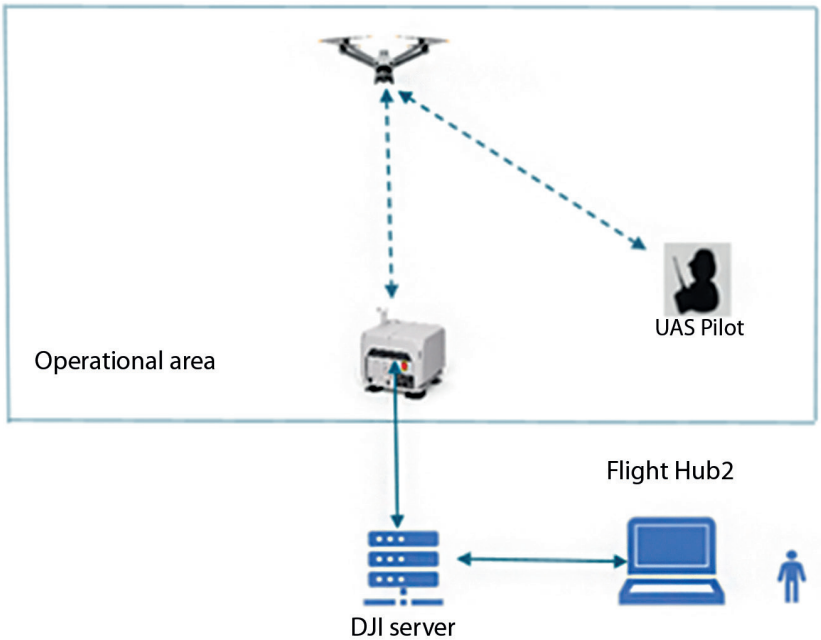

Figure 3.
Creating a network [authors' own editing]

The main features of the flight centre are: adding and creating real 3D models, mission planning, viewing recordings, live view streaming functions.

Data security: 27001/27017/27018 certified server, information security management system, access connection with multi-level protection mechanisms [16].

3. Operation

The first mission is the deployment phase, but before the deployment, the aircraft can use vision sensors to scan the environment and the conditions of the desired locations to quickly determine whether the area has strong GNSS signals. This new vision-based inspection and assessment significantly speeds up the process of selecting sites. The next process is to plan flight routes using high accuracy 3D models. Operators can perform visual flight path editing from a first-person perspective and preview simulated imaging results. This facilitates intuitive and efficient operation, and increases flight path planning and the accuracy of planned flight paths. During flight path planning, operators can frame a specific area in the 3D model (in our case, for example, a controlled area should be guarded by Dock 2) and the aircraft will automatically compare the area to be captured with the framed area during subsequent automated operations. In this way, the camera angle is adjusted to ensure that the same area is accurately captured on multiple flights.

After flight path planning, DJI FlightHub 2 FlyTo tasks use high-fidelity 3D models to automatically plan the optimal flight path, but operators can also select other modifiers to make the flight plan more accurate. For urgent tasks, the operator just needs to click on the subject and the aircraft will fly an efficient and safe route to the destination. During task management, the operator can order the established and defined flight path to the selected docking 2 unit if more than one docking 2 is available on site.

The task can be sorted by date/time selection. The task can be issued immediately, according to a pre-programmed exact date/time, or continuously if the selected program is in accordance with the aircraft battery capacity level (dock 2 will execute the task continuously when the aircraft battery level in the dock reaches 80% capacity) (Figure 4).

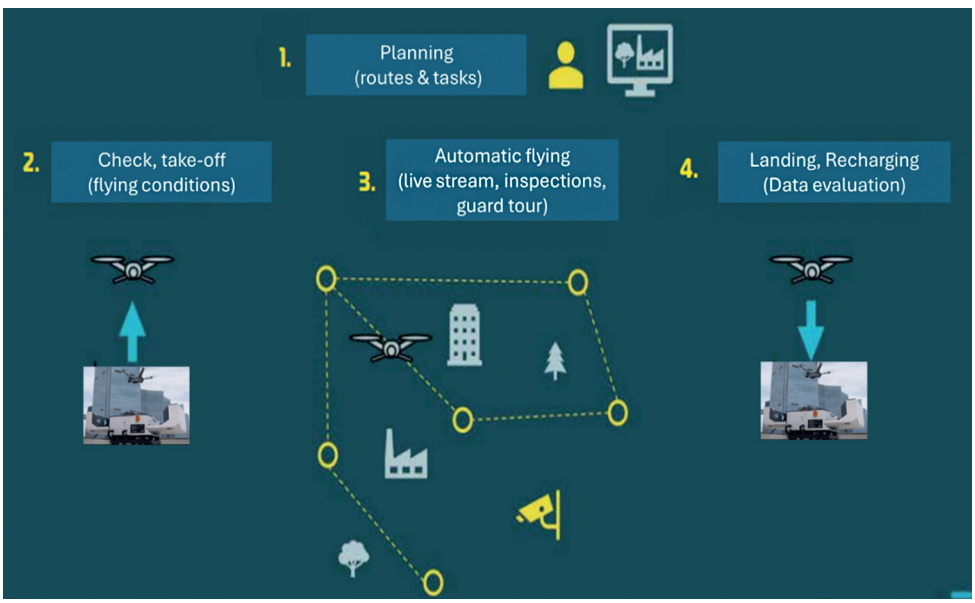

Figure 4.
DJI Dock 2 operation [authors' own editing]

Once the aircraft has completed its flight task, DJI FlightHub 2 uses the collected flight data to create highly accurate 3D models, faithfully recreating the operating environment. These models can be annotated, measured and downloaded for further testing/evaluation. Knowing that some critical assets are classified institutions, it is not allowed in most cases to open local networks to the World Wide Web, consequently only the use of internal standards is allowed. Based on the common standard protocols, the DJI Cloud API can be adapted to any network (third party cloud platforms) as long as the DJI Pilot2 (RC) or DJI Dock can access the third party platform server as a gateway device. DJI FlightHub 2 provides APIs to communicate with third party cloud platforms. Available API services include the transfer of media files, telemetry and livestream data, as well as map and flight path files, and the display of notifications on both FlightHub 2 and third-party platforms (Figure 5) [17].

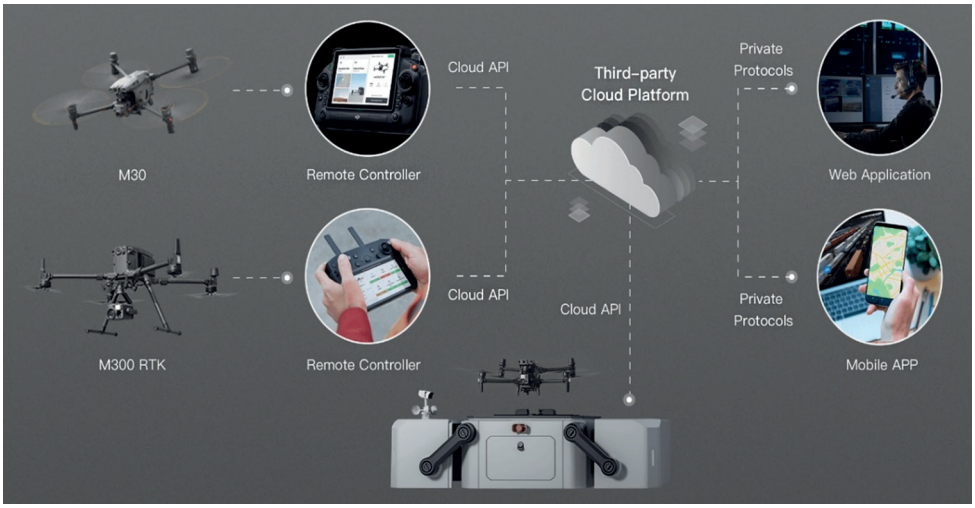

Figure 5.
Low-threshold access to third-party cloud platforms [14]

The communication links and protocols used can be adequately protected according to local standing operating procedures (Figure 6).

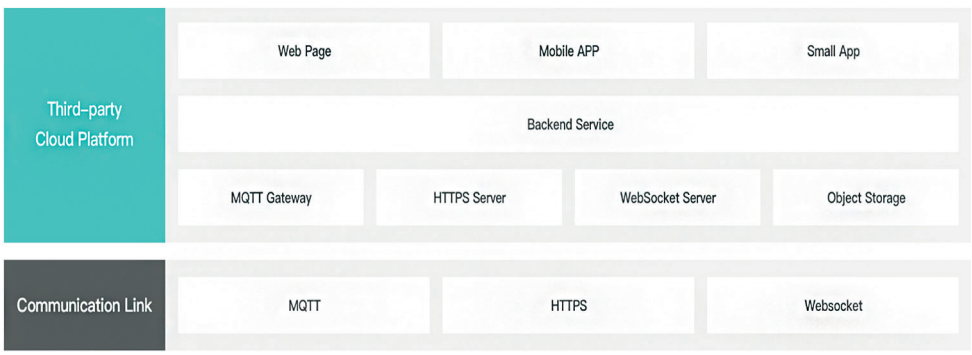

Figure 6.
Third-party cloud platforms and communication connectivity [14]

4. Conclusion, summary

The Dock 2 is a lightweight structure that offers high level of sophisticated operational capabilities and capacities with cloud-based intelligent functions that provide efficiency and quality for automated operations. More capable, yet noticeably smaller, the DJI Dock 2 easily and securely deploys Matrice 3D or 3TD drones.

The unit is easy to deploy, has IP 55 protection, provides a max effective operating radius of 10 km, provides an integrated environmental monitoring system (significantly reducing flight risks), cloud modelling, mission planning and tasking tools, private deployment options, application provisioning, 400 battery cycles, and supports third-party payloads. Finally, users can enjoy fast 2D/3D reconstruction and enhanced point cloud reconstruction capabilities with the newly developed DJI TerraAPI solution.

Based on DJI FlightHub 2 or a third-party cloud platform, even if DJI Dock 2 is installed in a remote region, you can control the flight and gimbal angle using the operator keyboard and mouse. When executing automatic flight tasks, the aircraft uses omni-directional obstacle detection and automatic obstacle avoidance features to increase the success rate of flight tasks. This is a very important factor for maintaining flight safety and for the subsequent execution of operations in a UTM/U-SPACE environment, even for BVLOS operations.

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DJI Dock 2 „egy drón a dobozban", fokozni az ember nélküli őrzés-védelem megoldását – tudományos kutatás a Duplitec Kft. közreműködésével

A DJI Dock 2 „drón a dobozban" a korábbi Dock 1 megoldás továbbfejlesztett változata, ahol egy kifinomultabb, agilisabb, mobilabb, könnyebb és hatékonyabb terméket vezettek be, hogy az megfeleljen a megbízható, teljesen autonóm drónműveleteknek kiterjesztett hatótávolság alatt is. A technológia legújabb fejlesztésével lehetővé válik a drónokkal történő, teljesen automatikus repülési műveletek megszervezése, megtervezése és végrehajtása, akár látótávolságon túli műveletek esetén is. Sok az olyan küldetés és feladat, amelyeket korábban veszélyes volt emberekkel végrehajtani, mivel az emberi erőforrás alkalmazása túl veszélyes volt, vagy nem hozott hatékony és kielégítő megoldást az állami szervek, a nemzetgazdasági ágazatok működése vagy a lakosság biztonságának garantálása szempontjából, továbbá fontos helyszínek ellenőrzésére, őrzésére,

védelmére vagy folyamatos megfigyelésére is szükség lehet. Most ezeket a problémákat a DJI Dock 2 és tartozékai segítségével megfelelő módon lehet kezelni. Használhatók drónnal végzett járőrözésekhez és védett területek körüli őrzött túrákhoz.

Kulcsszavak: *DJI Dock 2, teljes automatikus drónrepülés, műszaki képességek és sajátosságok, küldetéstervezés és -végrehajtás, működési feltételek, jogszabályok*

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