Abstract

The purpose of this study is to look at the threat of drones that are becoming a reality in the world, and to suggest ways to establish the Drone Defense System (DDS) for nation's critical facilities. If the 9/11 terrorist attacks were carried out by a civilian aircraft to change the paradigm of terror attacks, the threat is great because now the drone-based terrorist attempts have a way to secretly use drones while the safety of the terrorists has been guaranteed. The recent drone terrorism was enough to show the threat to everyone in the world. In addition, the movement of wind lanterns in the air caused a fire in an oil storage facility, causing great damage, showing how lethargic the defense system of the two-dimensional, nation's critical facilities on the ground is. To raise the need for preparedness against drone terrorist threats, the study analyzed cases of overseas drone terrorism and the threat of drones themselves, and studied DDS building and legal issues to prepare them. The basic concept of establishing the DDS is to establish the system in accordance with a step-by-step process called drone detection, identification and neutralization. The DDS should basically be prepared with a one-minute operational concept. This is because the time allowed to respond to drones that are trying to launch terrorist attacks is about one minute. No matter how good DDS equipment is built and operated, it will inevitably fail to defend itself if it misses operational response time. Therefore, DDS need to be equipped with surveillance and strike capabilities that automatically link detection, identification, and neutralization, and the establishment of high-level DDS in peacetime so that they can be prepared with one minute's operation until detection, identification, and neutralization.

[Keywords] Drone Threats, Drone Terrorism, Nation’s Critical Facilities, Drone Defense System (DDS), Drone-Related Laws

1. Introduction

This study is aimed at establishing the Drone Defense System (DDS) at nation's critical facilities to prepare for the threat of drones emerging as new threats. If the 9/11 terrorist attacks were carried out by a civilian aircraft to change the paradigm of terror attacks, the threat is great because now the drone-based terrorist attempts have a way to secretly use drones while the safety of the terrorists has been guaranteed.

The recent drone attacks and airborne threats were enough to show the threat to everyone in the world. Just on Sept. 14, 2019, a drone attack on Saudi Arabia’s state-run oil company by suspected Yemeni rebels in two areas reduced daily crude production by 50 percent, or 5.7 million barrels[1], and property damage about four million dollars caused by a fire in a low-oil tank in Goyang on a windfall on Oct. 15, 2018[2].

The reality is that the nation's critical facilities maintain a two-dimensional and flat defense system under the concept of defense
in the three zones based on the Integrated Defense Act and the Presidential Decree No. 28, so there is a lack of preparedness for the threat of three-dimensional drone terrorism through drones. Considering these factors, legal solution and deployment of DDS were studied to effectively prepare for the threat of drone attacks to nation’s critical facilities.

2. Realizing Drone Threats

Now drones are coming to us as a threat, despite all the positive uses. We will discuss how the drone threat has come, what it is, and how it’s becoming a reality.

2.1. Has the drone threat arrived?

When we ask people around you if a drone threat has arrived, everyone says it poses a threat. The reason why this question is so easy to say may be because we have often been exposed to situations caused by drones on TV or the Internet through domestic and international media. In this study, we conclude that drone threat has arrived even if we do not conduct survey unnecessarily. Answers to the arrival of drone threats can be expressed in just one word for “Yes.” This hasty conclusion is due to the fact that drones are posing a threat to the nation’s critical facilities and others that we should protect even faster than we realize.

2.2. What is the drone threat?

In order to find out what the drone threat is, we need to reach its essence. As we approach the essence of a drone, we can identify the four fundamental threats it poses, as in Figure 1.

First of all, drones are small things. The existing radar cannot identify them because they are too small. Therefore, equipment for special detection and identification should be developed and equipped to detect and identify drones that pose threats.

Second, the drone’s bombing has caused fatal damage. Previously, explosives that can be loaded into drones were not considered a threat due to the low weight of explosives, but now the explosive is big enough to deal a serious blow to nation’s critical facilities.

Third, the speed of the drone. The drones can travel an average of 72km/h, and can make a dash faster in the event of a final attack. Because it is difficult to have a system that can respond to such rapid drone threats, the threat is even greater. Therefore, it needs to have a skilled response system to respond to drone threats.

Finally, it takes a lot of budget to prepare for drone threats. The large budget itself poses a threat. Therefore, a strong will to prepare for drone threats from political leadership, social consensus and public support are required.

Kalishnikov, the maker of the AK-47 rifle, presented the KUB-UAV suicide bomber at the defense exhibition "IDEX 2019" in Abu Dhabi, the United Arab Emirates. The KUB is a 1.2 m-wide, 6-lb(2.7kg) explosive, flying for 30 minutes at 129km/h(2,150m/minute) and capable of striking targets within a radius of 60km.

2.3. Will the drone threat become a reality?

As an approach that could make drone threats a reality, in 1995, Barrie Boozhan answered, "When will the threat become a national security issue. This question can also be applied to when drone threats will become a reality.

As for when the threat becomes a national security issue, Barry Buzan said, "It depends not only on what kind of threat is and how the threat is perceived, but also on the intensity that the threat works." The determinants of the strength of the threat were viewed as
specificity of the threat, spatial proximity, probability of occurrence, seriousness of its consequence, and recognition of the threat as amplified by historical circumstances. If you apply the strength determinant of this threat to Korea against the drone threat, the intensity of the threat is a red light, as shown in <Figure 2>.

Figure 2. Realization of the drone threats.

The specifics of the threat, the proximity of time and space, the probability of occurrence, the seriousness of its consequence, and the perception of the threat are amplified by the historical situation.

In terms of the specific nature of the threat, the strength of the drone threat has been identified, and in time and space, drones are close to the nation’s critical facilities that we must protect, and the consequence can be expected as well as the probability of occurrence. Considering the past experience of North Korea’s bombing of a KAL plane and the sinking of a South Korean warship by surprise attacks on the Cheonan, it is believed that terrorist attacks by drones could occur as many times as possible depending on the political situation.

If the 9/11 terrorist attacks were carried out on civilian aircraft to change the paradigm of terror attacks[5], Now the attempt to use drones has become a guarantee for the safety of the terrorist, then the threat is even greater in that there is a covert way to use drones to carry out terrorism.

Figure 3. Overseas drone terrorism objectives.

As shown in <Figure 3>, a drone bomb supposedly floated by ISIS on Oct. 11, 2016, killed two people and wounded two others in Iraq, showing the drone became a striker[6]. On Aug. 5, 2018, seven soldiers were injured in a drone bomb attack while Venezuelan President Maduro was speaking at an event marking the 81st anniversary of the founding of the National Defense Forces in the capital city of Caracas[7]. And on September 14, 2019, oil production in Korea was 50 percent (5.7 million barrels) due to 10 drone attacks by Yemeni rebels, which are believed to be behind Iran in two Saudi Arabian oil refineries. Decreased terror attacks have raised global awareness of drone terrorism[1].

3.2. What is the goal of drone terrorism in Korea?

The case of terrorist attacks by drones here has not been confirmed, but the danger is already close to us. In particular, as the fourth industrial revolution and the use of high-speed Internet have become the world’s most hyper-connected society, drone terror preparation is becoming an important task as damage to nation's critical facilities can be linked.
As shown in Figure 4, the number of drone launches has been increasing every year since 2014 in area P73 in Seoul, the capital city, and P65 area in Daejeon, which has been off-limits, and the low-altitude fire accident in Goyang caused by the sky lantern on October 7, 2018 has shown how vulnerable it is to the public threat to the nation’s critical facilities, and the public opinion has been that it should be given to Sri Lankan. In September 2019, drones appeared in no-fly zones in the Gori and Hanvit nuclear power stations, raising awareness of drone terrorism.

4. Establishment of the DDS

As the threat of drone terrorism increases, the establishment of a DDS is becoming a public debate. Some key facilities are already in operation with DDS, some facilities such as Incheon International Airport are under construction, and the deployment of DDS, including state-run infrastructure, has become a pressing issue that can no longer be delayed. Under these circumstances, we will study the concept of establishing a DDS and how to deploy it.

4.1. Basic concepts for deploying DDS

The basic concept of building DDS is to establish DDS according to the step-by-step process of detecting, identifying and neutralizing drones[7], as shown in Figure 5. Drone detection is detected by radar and RF scanners, and drone identification takes place through EO/IR, and drone jammers are used to neutralize hostile drones.

4.2. Methods for building the DDS

Methods for establishing DDS can be established in variety depending on equipment construction cost and equipment performance. If equipment construction costs are high, equipment that has good performance can be equipped with them, and if equipment construction costs are low, equipment that has relatively poor performance will have to be built. As you can see in Figure 6, there is a way to build a DDS based on how to detect and identify hostile drones that are attempting major attacks, and how to disable them[6].

DDS systems can be established in a variety of ways depending on construction costs and equipment performance. Figure 7 compares the performance of each type of drone detection sensor in the deployment of a DDS, divided by the type of drone detection sensor: acoustic, RF scanner, radar, EO/IR, detection range, accuracy, tracking capability, identification capability, hover-ring target identification, and long-range flight target.

### Sorting: Equipment: Using purpose

<table>
<thead>
<tr>
<th>Detection radar</th>
<th>Drone Detection Dedicated Radar (maximum detection range: 18km (a); RCS 0.01m² criteria)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF scanner</td>
<td>Directional Detection with Drones (maximum detection range of 6km (a))</td>
</tr>
<tr>
<td>Video surveillance</td>
<td>EO/IR etc., maximum detection distance of 8km (a)</td>
</tr>
<tr>
<td>UTM</td>
<td>2021 scheduled to be introduced, equipped with a drone identification card</td>
</tr>
<tr>
<td>Neutralization</td>
<td>birds of prey, nets, guns, lasers, etc</td>
</tr>
<tr>
<td></td>
<td>WI Operation of key defense facilities</td>
</tr>
<tr>
<td></td>
<td>WI Disabling drones by radio disturbance</td>
</tr>
</tbody>
</table>

[Wi] Construction method varies according to cost and equipment performance.
identification[8]. Generally, composite sensors are recommended. When equipment equipped with composite sensors is built, drones can be detected in a variety of situations such as fog, clouds, and downtown areas.

**Figure 7.** Performance comparison of different types of drone detection sensors.

<table>
<thead>
<tr>
<th>Sortation</th>
<th>Acoustic</th>
<th>IR Scanner</th>
<th>Radar</th>
<th>IDS</th>
<th>composite sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>detection range</td>
<td></td>
<td></td>
<td>x</td>
<td>Δ</td>
<td>O</td>
</tr>
<tr>
<td>detection capacity</td>
<td>O</td>
<td>Δ</td>
<td>O</td>
<td>Δ</td>
<td>O</td>
</tr>
<tr>
<td>Accuracy</td>
<td>x</td>
<td>O</td>
<td>O</td>
<td>Δ</td>
<td>O</td>
</tr>
<tr>
<td>Tracking status</td>
<td>x</td>
<td>O</td>
<td>O</td>
<td>Δ</td>
<td>O</td>
</tr>
<tr>
<td>identification ability</td>
<td>x</td>
<td>Δ</td>
<td>Δ</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Hovering target</td>
<td>O</td>
<td>O</td>
<td>x</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Automatic Flight Target</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Generally, complex sensors are recommended, and the radar detection distance depends greatly on the target size.

There are many thorny issues that need to be solved in order to establish and operate a DDS on nation’s critical facilities. First, there is a lack of empirical data on the capabilities of relevant equipment in relation to the deployment of the DDS, and there is also difficulty in securing budget to purchase proper equipment. It also needs to be discussed whether detection-identification-force equipment should be secured individually or built into an integrated defense system with composite sensors. And most of all, acting as a constraint is a legal matter. Under the current radio wave law, the use of jammers causing radio disturbance is prohibited. <Figure 8> outlines legal restrictions on the deployment of a DDS.

**Figure 8.** Legal restrictions on the establishment of the DDS.

<table>
<thead>
<tr>
<th>Sortation</th>
<th>legal availability</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>drone patrol</td>
<td>O</td>
<td>Possible after flight approval</td>
</tr>
<tr>
<td>aerial photography</td>
<td>O</td>
<td>Available after Air Shot Authorization</td>
</tr>
<tr>
<td>drone detection</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>drone strike</td>
<td>O</td>
<td>Radio wave law (using jammer), aviation safety law, airport facilities law and anti- terrorism law need to be revised.</td>
</tr>
<tr>
<td>Inspecting facilities</td>
<td>O</td>
<td>Possible after flight approval</td>
</tr>
<tr>
<td>pesticide spraying</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

In common, the "Location Information Act" needs to be revised.

What is possible through current legal approval are drone patrols, aerial photography, drone detection, drone utilization facilities check, drone control, and so on, and what is not possible is for drone attacks[9]. In order to strike a terrorist-driven drone, the radio wave law must be revised to allow the use of jammers. In addition, the Aviation Safety Act, the Airport Facilities Act and the Terrorism Prevention Act should be amended in conjunction with each other. In addition, the Location Information Act should be amended in common, and it is currently not possible to identify an individual's location information under the Location Information Act.

4.3. Demand for change of the concept of protection in the three zones of nation’s critical facilities

Nation’s crucial facilities are designed to be prepared for threats in accordance with the concept of protection in the three zones. This is a ground-oriented concept that does not take into account the threat of drones. The first zone is that the area is 500m to 1.5km from the fence, which is organized in consideration of the mortar range. The second zone (main defense zone) is located up to 500m from the fence and takes into account the effective range of the rifle[3]. The third zone (core defense zone) is an area with nation’s critical facilities inside the fence[10].

On the other hand, the formation of the drone defense zone considered the drone’s flight speed of 129km/h per minute (2,150m/minute), and the radar(3km) and RF scanner(2km) detection range, as seen in <Figure 9>. Areas of interest (detection) will be divided into areas ranging from 2km to 3km, areas (border area, identification) from 500m to 2km, areas (main defense zone, incapacitation) from fence to 500 meters, and areas from fences to core facilities within. In contrast to this drone, the formation of the three-point protection zone will require flexible arrangement of the three zones depending on the performance development and improvement of drones and equipment.
4.4. Establishing a one-minute drone defense system

The DDS should basically be prepared with a one-minute operational concept. This is because when a drone that tries to attempt a terrorist attack at 2,150m per minute, the time allowed to respond is about one minute.

No matter how good DDS equipment it makes and operates, it will inevitably fail to defend itself if it misses operational response time. Therefore, the DDS should be equipped with surveillance and strike capabilities that automatically link detection-identification and force, as shown in <Figure 10>, and maintain the high-level DDS in a normal manner to prepare for detection-identification-neutralization with one minute's operation. In addition, if drone terrorism attacks are carried out near facilities, it is necessary to establish a close cooperation system with related agencies to arrest pilots and to conduct regular training during normal times.

5. Conclusions

In the above we learned about the threat of drones and their defense system. The threat of drone terrorism is increasingly dangerous, as seen in drone terrorism cases at home and abroad.

It is important to operate a system that can prepare for drone defense with a one-minute operational concept by equipping automated systems that are fully connected to detection, identification, and disable way.

The implications of establishing a DDS against drone threats through the above research are as follows:

First, the number of terrorist attacks using drones is on the rise. The drone attacks are becoming more likely to be carried out because they are equipped with guns, explosives, etc., and remote control allows terrorists to attack targets in a safe environment at low cost.

Second, the government needs to prepare for drone terrorism on the nation's. As the possibility of using drones to achieve its political goals grows, nation's critical facilities may be subject to drone terrorism, so the DDS will have to be built before the threat becomes a reality.

Third, it is necessary to establish a dedicated organization and expand the number of professionals in preparation for drone terrorism. Since drone terrorism is a technical threat that the existing defense system cannot respond to the threat in time and physically, it will have to operate the actual DDS by effectively operating the deployed equipment, rather than simply deploying the equipment.

Finally, in order to properly establish a DDS, current legal restrictions must be addressed. Although the principle of using radio wave environment should not hinder or block the use of other people's radio wave, the DDS, such as the use of jammers, should be able to operate within a limited scope to protect the people and prevent terrorism for public safety.
The research focused on the need to establish a DDS and the concept of deployment. Further in-depth research is required on specific performance of detection, identification, and deactivation equipment related to deployment equipment.

6. References

6.1. Journal articles


6.2. Conference proceedings


6.3. Additional references


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