

Introduction to Intelligent Counter Drone Technology for Nuclear Facilities

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1. Introduction

Drone threat has arisen throughout the world as one of the new threat which is difficult to counteract. It has been emerging with the development and popularization of commercial drones since early 2010s. They are a rotary wing shape and use a camera to record or control the drone. Usually their flight time is less than 30 minutes and their speed is less than 20 m/s (72 km/h). As illustrated in Table I, they pose a relatively low threat in comparison with military drones. Commercial drones have been developed for leisure purposes, however, their relatively weak numbers of the specification are enough to be a critical threat that we should prepare seriously.

Table I: General Drone Specification

	Commercial	Military
Shape	Rotary wing	Fixed wing
Flight Time	< 30 min	> 1 hr
Speed	< 72 km/h	> 100 km/h
Weight	< 4 kg	> 10 kg
Price	millions ₩	> Tens of millions ₩

As shown in Table II and Table III, drone has been a continuous threat to nuclear power plants and airports. In Table II, the numbers increase rapidly from 2022 because a drone detection equipment was installed in 2022.

Table II: Drone Caught Cases for Nuclear Power Plants

구분	2017		2019		2020		2021			2022			합계		
	신고	적발	신고	적발	신고	적발	신고			신고			신고		
							탐지	육안	적발	탐지	육안	적발	탐지	육안	적발
고리			11	7	4	4	5	1	2	77		26	82	16	39
새울	1	0	2	1						1	1	26	3	26	4
월성															0
한울			1	0											1
한빛	1	1	5	3						1	1				7
합계	2	1	19	11	4	4	5	2	3	103	1	30	108	28	49

Table III: Drone Caught Cases for Incheon Airport

Year	2020	2021	2022	2023.7	Total
Case	57	173	152	62	444

For a nuclear power plant, a drone is not a big threat because a drone itself cannot make any trouble through

the buildings in a site. In particular, the reactor building is known to endure a crash with fighter plane. But when it comes to secondary damage due to a drone, the range of possible threat becomes different from that of direct damage due to a drone crash. For instance, a drone crashing into a switchyard is sufficient to cause an accident and potentially a reactor trip. Furthermore, the use of small explosives on drones can also cause a reactor trip from any location within the site. To prepare for such scenarios, the Design Basis Threat (DBT) is integrated into nuclear reactor design, and evaluations have also been conducted on drone threats that are currently not reflected in the DBT.

However, despite the 18.5 km radius no-fly zone applied to domestic nuclear power plants, the operational range of equipment capable of countering drones is limited to only a 3km radius. This paper aims to introduce a new drone response system designed to overcome the limitations of such conventional counter-drone equipment.

2. Methods and Results

2.1 Concept of the System

Korea Atomic Energy Research Institute (KAERI) performed the ‘Development of Intelligent Response Technology for Illegal Drones’ project, a multi-ministerial task involving the Ministry of Science and ICT, the Ministry of Trade, Industry and Energy, and the National Police Agency. From 2021 to 2025, KAERI spearheaded the development of an anti-drone system with a five-year budget of approximately 44 billion KRW.

As illustrated in Fig. 1, IGAAD (Integrated Ground- and Airborne- based Anti-Drone system) system introduces an aerial-based expansion of equipment and system concepts to compensate for the limitations of conventional ground-based systems. The aerial-based system is realized through the ‘Drone-Cop’ and its integrated miniaturized, lightweight mission equipment. This enables drone response activities including detection, identification, and neutralization, even within the 18.5 km no-fly zone of nuclear power plants and the 9.3 km radius of airports.

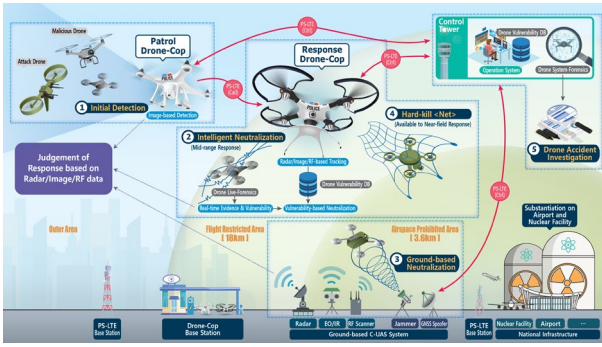


Fig. 1. Conceptual figure of IGAAD system

This system features three distinct advantages over existing systems. As shown in Fig. 2, these include the 'Drone-Cop' concept, 'Live Forensics' technology, and 'Intelligent Neutralization' technology. As previously described, the Drone-Cop concept significantly extends the response range of ground-based systems. 'Live Forensics' is a technology that acquires real-time information from an illegal drone while it is still airborne, prior to its neutralization. Lastly, unlike conventional jammers or spoofers, the 'Intelligent Neutralization' technology neutralizes only the intended target without emitting radio interference. This advanced technology seizes control of the illegal drone and forces it to land at a designated location with preventing secondary damage at critical national infrastructures such as nuclear power plants.

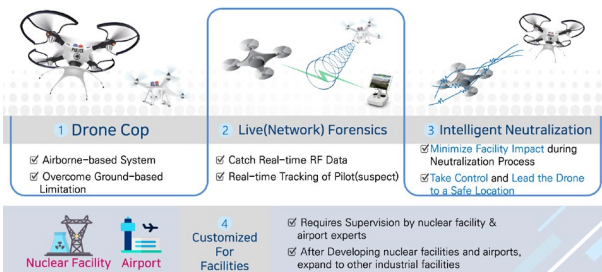


Fig. 2. Three features of IGAAD system

2.2 System Development

To implement the system shown in Fig. 1, internal and external interfaces were configured as shown in Fig. 3. The diagram briefly illustrates the Ground-Based System (GBS), the Ground Control System (GCS) for the aerial-based system, and the Integrated Control System (ICS) that unifies both, along with the communication networks and management servers connecting each component. The actual implementation of the ICS is presented in Fig. 4.

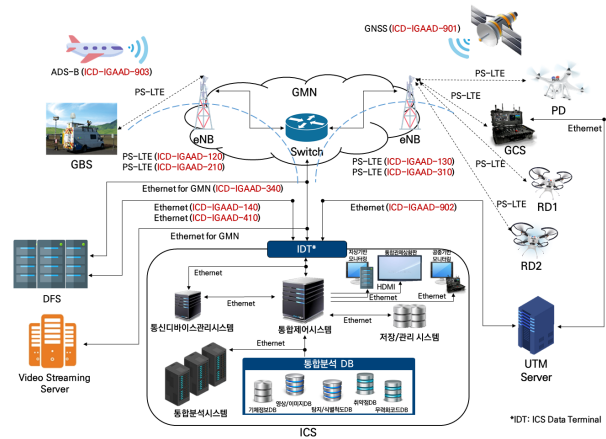


Fig. 3. Interface configuration of IGAAD system



Fig. 4. Picture of ICS operation room

3. Conclusions

An anti-drone system has been introduced to counter illegal drone at facilities with wide no-fly zones and high risks of secondary damage, such as nuclear power plants. Through this IGAAD system, it is possible not only to respond to illegal drones at a long distance but also to neutralize them without secondary damage, such as drone crashes or electromagnetic interference on electronic equipment within the facility. In the future, it is necessary to develop a high-maturity system by conducting tests and demonstrations in more diverse environments.

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