Assessing a Drone Threat to Nuclear Facilities

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1. Introduction

Unmanned aerial vehicles (UAV)[1], as also known as drone, are considered as innovative technology in the areas of package delivery, surveillance on hazardous zones, agricultural applications, and so on. However, as everything has pros and cons, UAVs can pose a new significant threat to national critical infrastructure such as nuclear facilities.

UAVs can be made use of in several ways in order to exacerbate security of nuclear facilities. It can be used to deliver explosives or hazardous materials, or to observe a target facility with an espial purpose. There had already been several incidents to provide insights how UAVs can be a threat to nuclear facilities. It is important to take a close look at those incidents because we are able to evaluation current security systems of nuclear facilities.

In this paper, we would like to take a close look at several incidents involved with UAVs. The first incident is the radioactive drone in Japan in 2015. The second incident is the North Korean drone to Seong-ju in 2017. The last incident is the Abqaiq-Khurais attack in Saudi Arabia in 2019. We can assess a drone threat from those incidents. We are able to learn what adversaries can be achieved by making use of UAVs. As well, those incidents provide valuable clues what resource adversaries require to make use of UAVs. Finally, those lessons and clues will provide insights how we can prepare and response a drone threat.

2. Drone Incidents

2.1. Radioactive Drone in Japan

Tokyo police announced that a man was arrested in the charge of flying a drone carrying radioactive sand on to the roof of Japanese prime minister's office in 2015 [1]. The man protested against Japanese government's energy policy. Tokyo police said the radioactive material seems to be Cesium with low radioactivity. Fortunately, no one was hurt from the incident.

However, it was enough to trigger security alert. The drone in this incident was Phantom built by DJI, the famous Chinese drone manufacturer. The price of the drone was merely several hundred of USD. The protested man did not require special capability or knowledge on drone operation.

Figure 1. Radioactive Drone in Japan

2.2. North Korean Drone to Seong-ju

A North Korean drone was found in a mountain near inter-Korean border in 2017 [3]. The drone equipped with a camera was sent to take pictures of THAAD launchers in Seong-ju. It seemed to be crashed due to fuel shortage after traveling more than 500 km.

The drone was 1.8 m long and 2.4 m wide. Its body was fabricated with fiber glass. Its engine was a gasoline engine with two cylinder and two strokes. Its navigation equipment was a Canadian micro-computer for a UAV autopilots. An analysis showed that drone building seemed not easy but not state-of-art nor cutting-edge technology. Also, it explained the reason why it did not trigger alarms from air defense network.

Figure 2. North Korean Drone [3]

2.3. The Abqaiq-Khurais attack in Saudi Arabia

Ansar Allah Houti force deployed hundreds of drones with explosives and succeeded to destroy the oil refinery in Abqaiq-Khurais, Saudi Arabia in 2019 [4]. The done was known as Qasef-1 or Qasef-2K, which

1. In this paper, we are using the terms, UAV and drone, in the same meaning.

were UAV models used by Houthi forces in Yemen [4]. It was based on the design, dimensions, and capability to Ababil-T UAV manufactured by Iranians.

The drone was 2.9m long and 3.3m wide. Its body was also fabricated with fiber glass. Its engine was a 3W-101i B2 engine manufactured by 3W-Modellmotoren Weinhold GmbH in Hanau, Germany. Its mechanical parts were Hitec HS-7955TG titanium-gear servomotors to control the UAV. It uses Digi microprocessors and electronic components from STMicroelectronics.

The attack devastated the Oil refinery in Abqaiq-Khurais. However, the drone used for the attack was evaluated as "rudimentary."

Figure 3. A drone for Abqaiq-Khurais attack [4]

3. Resources required to build or operate Drones

In this section, we would like to look into resources and capabilities that an adversary might require to make a use of a drone. At first, we would like to estimate overall cost to build a drone. Then, we would like to cover additional capabilities or effort required to operate a drone.

3.1. Cost Estimation to build a drone

Based on the analysis information revealed from incidents such as North Korean drone and the Abqaiq-Khurais attack. We are able to estimate overall cost to build a drone to carry out long-distance missions. Those drones were manufactured by almost state-level actors. An adversary, who would like to achieve their goal to a nuclear facility, might not need all functions that those drones have. However, cost estimation based on those state-level drone might provide valuable insight to assess financial ability or support that an adversary might need to carry out drone strike.

We investigated overall costs on component level from various sources. The cost of fiber glass, which is required to build a drone body, is merely from 30 to 40 USD per 40cm X 50m [5]. The dominate cost to build a drone body is not up to the material cost but up to personnel expenses. We estimated the cost of engine based on the engine used for Qasef-1. The engine cost is around 1,700 USD. It can be ordered or purchased from the manufacture's website [6]. The cost of the drone controller to navigate to the target was estimated from the North Korean drone. The North Korean drone used MP2028 by the Canadian manufacturer [7]. It provided functions for attitude hold, airspeed hold, or GPS waypoint navigation. In order to mechanically control a drone, gear servomotors are required. The cost was estimated from Qasef-1 drone. It used HS-7955TH manufactured by the company named, Hitec [8]. We estimated Qasef-1 might used five servomotors, one for fuel control to the engine, four for wing control. It can be ordered or purchased from Amazon.

Components	Unit Cost (USD)	Quantity	Cost (USD)
Fiber Glass (Body)	30~40 (40cmX50m)	10	400
3W-110i B2 CS Engine	1,700	1	1,700
MP2028 (Pilot Controller)	3,500	1	3,500
HS-7955TH (Gear Servomotor)	180	5	1,800
Total Cost			7,400

We did not considered costs for other equipment such as electronic or control wire, fuel tanks, and so on since those are not dominant cost factor for build a drone.

3.2. Capability to operate a drone

Now, we would like to take a look at capability required to operate a drone. In this section, the meaning of capability is technology or skilled personnel required to deploy a drone to a target.

There are several open source projects to build, repair, customize, and experiment with drones. Some of those projects provides open source software platforms including tutorials supporting autonomous flight such as Paparazzi UAV [9], ArduPilot [10], Dronecode [11], LibrePilot [12], Flone [13], and so on.

A software platform for autonomous flight focuses on how to route drone from a starting point to a destination. One of challenges for drone navigation is how to land a drone safely. Unfortunately, those drones we concern here do not need safe landing.

4. Conclusion

In this paper, we have taken a close look at three drone incidents. From those incidents, we estimated the cost of drone building and the capability of drone operation. From those estimation, we came to realize that making use of drones against nuclear security was not easy but not impossible either. There are number of hardware providers and open source information that an adversary might make use of building their own

customized drones. Then, the big question lying on us is how to prepare and response the drone threat.

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