A technician in Fukushima oversees key flight planning details before the Penguin C's first flight over the Daiichi nuclear plant (Courtesy of Clear Pulse)

Nuclear reaction

This commercial aerial system is being tailored to monitor and mitigate the fallout from disasters at nuclear powerplants. **Rory Jackson** reports

In March 2011, the Daiichi nuclear power plant at Okuma, Fukushima, suffered three nuclear meltdowns, three hydrogen explosions and widespread leakage of radiological contaminants, caused by the Tohoku earthquake and subsequent tsunami.

The radiation unleashed into the atmosphere resulted in a government-ordered evacuation zone that gradually reached 20 km in diameter and required the movement of around 154,000 nearby residents.

With a government commission having found that the Tokyo Electric Power Company failed to meet basic safety requirements, a number of measures have been taken to prevent a repeat of the disaster's various impacts.

For example, new sea walls have been built to better prevent tsunamis from flooding and damaging the plant's infrastructure, and a 1.5 km 'ice wall' of frozen earth has been installed to prevent irradiated or contaminated water flowing from the premises.

Most recently, a Penguin C UAV from UAV Factory has been acquired by local company Clear Pulse, to be used in the event of another disaster. In such a situation, the fixed-wing UAV will perform airborne radiological surveys to detect, study and map the radiation levels. These flights will then give a better idea than before about the safety and evacuation decisions needed.

Clear Pulse manufactures radiation measurement products, and its contract with UAV Factory, signed in 2018, covers delivery and various follow-up support services for the Penguin C and its ancillary equipment.

The company notes that when radioactive material is released into the air after a nuclear accident, it is important to know its concentration in real time, to

determine how best to reduce the risk of exposure to nearby residents.

The most reliable way to gather that knowledge is to measure the radiation directly. By using a UAV, Clear Pulse can reduce the risk of exposure to its staff and therefore make the measurement process safer, since they can launch and fly it some distance from the nuclear plant – and, unlike manned aircraft, they wouldn't be putting a pilot in harm's way.

The aircraft will be operated through Clear Pulse's subsidiary JDrone, which successfully carried out the first acceptance flight trial of the Penguin C over Fukushima in May. Clear Pulse's role will be to oversee the operation and handle the processing and analysis of radiological data.

UAV Factory's launch catapult collapses to fit into a man-portable container for ease of transport (Courtesy of Clear Pulse)

Project requirements

The origins of the contract came from an inquiry that Clear Pulse received in 2017 from one of its (unnamed) customers who was studying aerial radiation monitoring. The subject of UAV Factory's Penguin C arose, hypothetically as a candidate aircraft to be used if ever another nuclear accident occurred.

To ensure satisfactory performance during a nuclear crisis, Clear Pulse drew up a list of requirements for the project's UAV. First, it would need to have long endurance, and have a distance of at least 5 km between the UAV and its GCS to keep the operator clear of the radioactive zone.

The system would also need to be fully autonomous, with an autopilot capable of integrating and operating a radiation sensor payload. Lastly, it could not be dependent on a runway; the launch and landing processes would need to be flexible, as the ground team might be forced to move at any moment.

According to Clear Pulse, although it and JDrone were familiar with a number of locally manufactured and potentially suitable UAVs in 2017, many of them were not yet at full technological readiness. The Penguin C on the other hand was fully commercialised, with its own hardware, software and customer support. These were the main reasons for its eventual selection.

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While JDrone and Clear Pulse are continuing flight trials to determine the optimum protocols to follow during a nuclear accident (depending on its nature and scale), a few key options and models for how to conduct the operation are available. The companies are also experimenting with the best model of radiation detector to install into a payload for the UAV.

The Penguin C

The Penguin C is a twin-boom aircraft (described in *UST* 1, November 2104) with a 3.3 m wingspan and measuring 2.3 m long. It is built largely from carbon and fibreglass composites, which give it a MTOW of 23 kg and a payload-carrying capacity of up to 4 kg, and is launched by catapult.

As mentioned, being able to fly long-endurance missions was a critical requirement for the end-user in Japan. Accordingly, the Penguin C is capable of flying for up to 20 hours, at a cruising speed of 68-79 kph.

Its endurance and cruise (as well as a top speed of 115 kph) are enabled by the company's own UAV28-EFI engine (described in *UST* 19, April/May 2018). This is a two-cylinder, two-stroke, electronically fuel-injected gasoline engine that provides up to 150 W from its starter/generator for onboard systems, payload included.

It has undergone highly accelerated lifetime testing to identify and eradicate long-term points of failure that might occur after hundreds of hours of