peo DETECTION

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Autonomous Airborne Radiation Monitoring (AARM) System

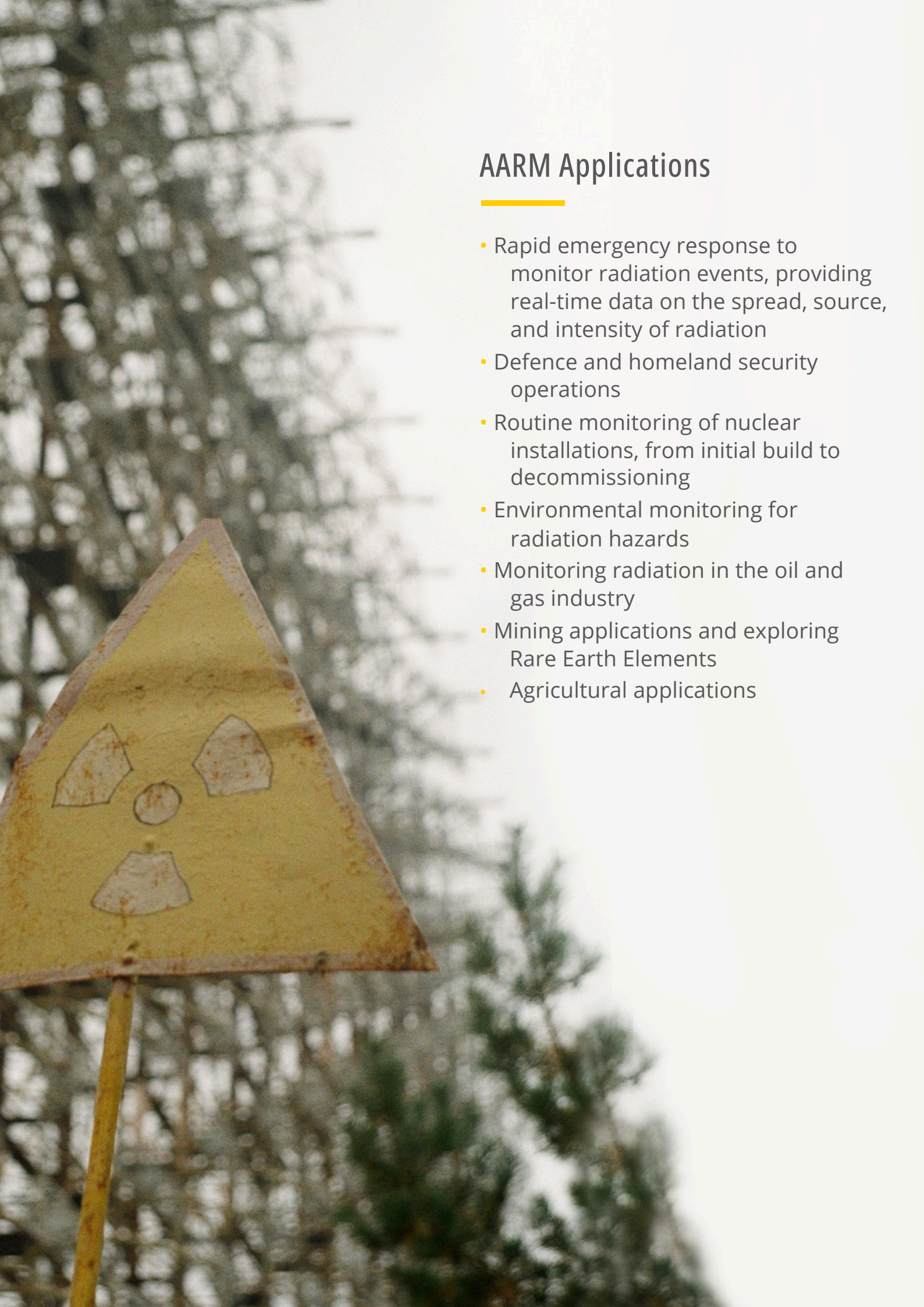
Real-time location, measurement, and mapping of radioactivity using a drone-based payload

The AARM System

The Autonomous Airborne Radiation Mapping (AARM) system provides a full radiation detection system which can be mounted to any multirotor drone system.

The Kromek Offering

- AARM payload system for use on drones containing Kromek's proven radiation detectors
- iOS based app for data visualisation
- A range of both cloud based and non-cloud based communications options
- Optional provision of an accompanying drone system, although customer own drones can be accommodated due to the AARM system's flexibility
- System training, either virtually or at the client site



AARM Applications

- Rapid emergency response to monitor radiation events, providing real-time data on the spread, source, and intensity of radiation
- Defence and homeland security operations
- Routine monitoring of nuclear installations, from initial build to decommissioning
- Environmental monitoring for radiation hazards
- Monitoring radiation in the oil and gas industry
- Mining applications and exploring Rare Earth Elements
- Agricultural applications

Benefits of Drone-Based Mapping Operations

- Minimised operator risk, as data can be collected when at a safe distance from the radiation source
- Pre-programmed flight paths to allow consistent and targeted scanning
- No operator shielding, thereby giving accurate count information
- Rapid response
- Wide area coverage

Scan Areas with Changing Terrain

The patented LiDAR system on board the AARM system allows the height above ground to be determined, as opposed to simply recording altitude levels. This information means that the radiation levels can be corrected to the levels one meter from the ground to give an accurate uniform radiation map of an area. Changing terrains in both rural and urban areas present no problem to the AARM system, as the system incorporates and corrects different heights above ground and drone flight heights, meaning the system can be used in hazardous areas with trees, fences, buildings, steep slopes and dangerous ground.

Benefits of the AARM System

- Scan areas with changing terrain
- Mission versatility with the ability to correct for different drone flight heights
- Drone versatility, whereby the system can be attached to any multirotor drone
- Suitable for missions anywhere in the world, with a large operating temperature range for the detectors
- Versatile detector options
- Enhanced spectral resolution to allow distinction between NORM and real sources
- Isotopic fingerprinting with spectral data sent every one second
- Rapid, more detailed surveys

AARM Payload

Single or Dual Detector Options

The AARM system houses Kromek's proven radiation detectors, which are used all around the world for a wide range of applications. Kromek makes detectors with ultimate radiation detection performance with world leading small form factor. This balance of size and detection capability make the systems ideal for use for aerial radiation mapping.

Both single and dual detector configurations are available, allowing flexibility to choose the best detector configuration for the application.

Detector	GR1	SIGMA 50	TN15	D3S
Gamma Detection	P	P		P
Neutron			P	P
Detection Detector Material	CZT	CsI(Tl)	Li(F) neutron detector	CsI(Tl) Li(F) neutron detector
Detector Size	10 x 10 x 10 mm 0.4" x 0.4" x 0.4"	25.4 x 25.4 x 51mm 1" x 1" x 2"	Neutron detection only	25.4 x 25.4 x 25.4 mm 1" x 1" x 1"
Resolution	<2.5% FWHM at 662 keV	<7.2% FWHM at 662 keV	Neutron detection only	<7.2% FWHM at 662 keV
Application	Higher resolution, lower sensitivity option for high dose areas	Lower resolution, higher sensitivity option for low level source location	Thermal neutron detection	Combined gamma and neutron detection

GR1 Spectrometer

SIGMA 50 & SIGMA 25

TN15

D3S

Communications Options

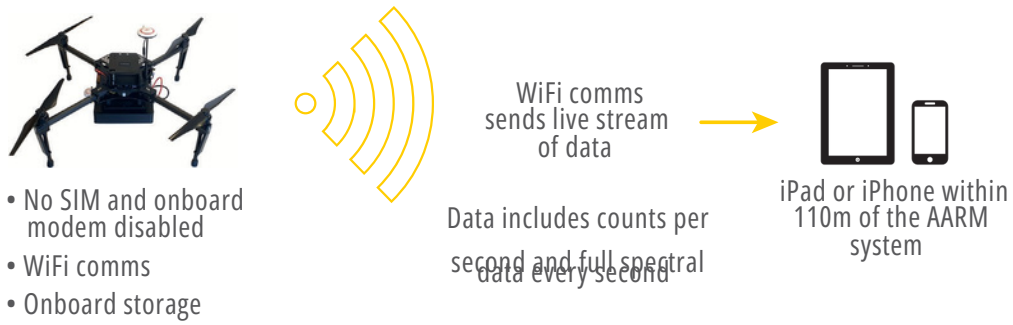
The AARM system offers both cloud hosted and non-cloud hosted data options.

Cloud Hosted Data Option

The AARM system can be fitted with a client SIM card to provide cellular communications to a secure server, allowing data to be viewed anywhere in the world.

Non-Cloud Hosted Data Option

If cloud communications are not an option, the AARM system can still relay data to the operator on the ground. The AARM system can communicate with an iOS device on the ground with a range of 110m, allowing real time data transfer. If the drone flies further than 110m from the on-ground iOS device, the data will be saved on the AARM system for transfer when the drone comes back into the 110m range.



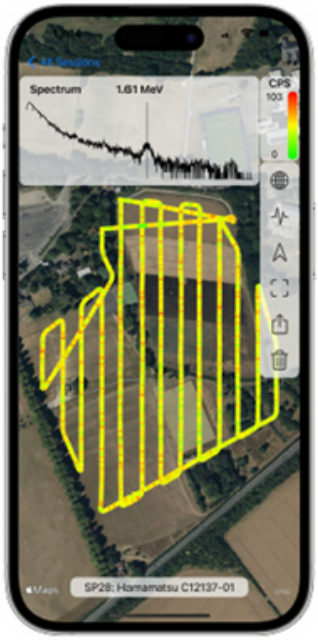
Secure drone WiFi hotspot*

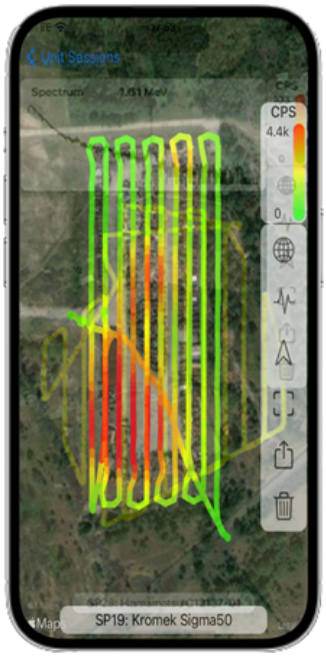
* If WiFi is not available, the onboard storage for after ight transfer is available

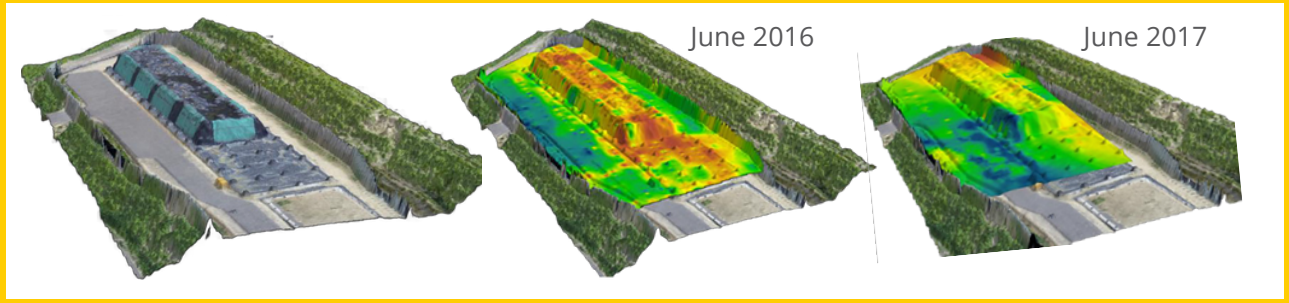
Data Visualization

The AARM system delivers metre resolution maps of radiation including over high dose areas and inaccessible locations whilst minimising the risk of operator exposure. It allows a level of spatial resolution not previously achievable in radiological hazard hot zones.

AARM measures and maps radioactivity and the isotopes present in real-time significantly speeding and improving the efficiency of radiation detection and decision making.
All data is accessed via an iOS app, available on the Apple App Store.
Gamma counts per second and spectral data are sent to the app every second. The app offers data visualisation, presenting radiation intensity as a colour overlay on a map, following the survey path. The data is visualised in real time, continuously updating at a rapid 1Hz refresh rate. The colour intensity scale, located at the top-right corner of the screen, helps users interpret radiation levels instantly and automatically scales depending on the maximum count rate. For units with multiple sensor packs, it is easy to toggle between each sensor.







Main pic: a drone undertaking an aerial survey over contaminated fields in Fukushima, Japan. Below: series of images from a repeated study showing a heat map from stored contaminated debris. (L) General picture of the site (C) survey undertaken in June 2016 (R) survey repeated in June 2017 showing the change in the distribution of radioactivity over time.

Identifying Isotopes

The AARM system transmits counts per second and spectral data every second, meaning that trained individuals can view and adjudicate spectral data.

Exporting Data

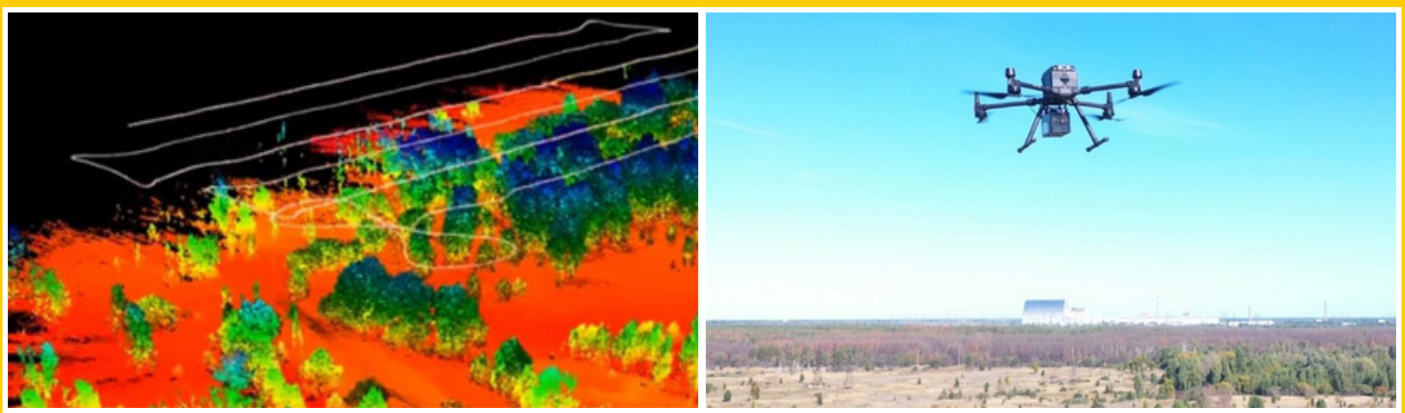
The Export Screen facilitates exporting data in the following formats:

CSV Energies: This format includes location information, intensity in CPS (Counts Per Second), and the calibrated spectrum collected at each location. The gamma events are exported in keV (kilo-electron volts). The export occurs at a rapid 1Hz rate.

CSV Channels: Similar to the previous format, this option exports location information, intensity in CPS, and the spectrum. However, in this format, the spectrum is exported as raw ADC (Analog-to-Digital Converter) channel values. This allows for the utilisation of external calibration in post-processing. Export also occurs at a rate of 1Hz.

JSON: This format retains all the raw data collected during the survey without any preprocessing. The export sample rate depends on the actual hardware configuration, typically at 10Hz.

Chernobyl's ‘Red Forest’ - one of the most radioactive places on Earth - has been surveyed several times by UK scientists using a fleet of drones equipped with Kromek detectors



Drone flying over the Red Forrest: Each survey route is saved as a collection of GPS waypoints, altitudes and velocities allowing the same survey to be conducted repeatedly to study any change in the distribution of radioactivity over time.