# HELINUC: AIRBORNE GAMMA MAPPING SYSTEM

# OF CEA

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**Abstract**

The CEA/DAM has a number of high-capacity sodium iodide gamma detectors and high performance germanium detectors used for operational response in nuclear security events. The detectors are positioned in packaging adapted to their use: transport suitcases, measuring container. One of the systems is the HELINUCTM airborne gamma detection system. A container is loaded with 16 liters of sodium iodide scintillation detectors. Two germanium detectors installed on either side of the container can also be deployed. The HELINUCTM system makes a flight over a defined zone and gives a radiological gamma mapping of the surveyed area. The system must face several challenges to be operational: its team must regularly be trained on material and software to be fully operational 24h/7d. Organized exercises contribute to train team and to improve collaboration between international teams. The particularity of the HELINUCTM system comes from its obtaining of two supplemental type certificates and a PART 145 agreement which conduct CEA members to ensure nuclear safety missions while respecting aeronautical regulations.

## PRESENTATION OF THE HELINUCTM SYSTEM

The HELINUCTM system has been developed since the early 80’s by the CEA/DAM. It is a French operational airborne gamma mapping system installed on helicopters. HELINUCTM is developed and implemented by the CEA/DAM at the benefit of French nuclear intervention actors (Ministry of Interior, Ministry of Defense), civilian nuclear operators (INTRA Group) and national public authorities and international agencies (IAEA...).

The main missions of the HELINUCTM system are:

* The realization of radiological references of large agglomerations, civilian and military installations;
* Securing major events;
* Emergency response in case of an incident/accident at a civilian or military site and the search for emission points;
* Searching for point sources;
* International assistance.

The HELINUCTM system is composed of one or two sodium iodide detectors installed under the helicopter (as in Fig. 1) or on both sides of the helicopter (as in Fig. 2) and two germanium detectors; a radio-altimeter to record the ground clearance; a GPS for the position; an airborne recording bay installed inside the helicopter and a PC to visualise data. The flight parameters are sent to the pilot through a tablet: the usual flight parameters are 40 meters of ground clearance, 70 km/h of speed and a line spacing of about 80 meters. These parameters allowed a surveyed area of about 5 to 10 km2/h.

Each second, a gamma spectrum and the position of the helicopter in space are recorded. Data are analysed in real time by one or two operators. One hour after landing, a first estimation of the radiological estate of the surveyed zone can be given.

Two supplemental type certificates (STCs) validated by the European Aviation Safety Agency (EASA) in 2016 allow the installation of the HELINUC system on two types of helicopters: AS 355 and EC 145. CEA/DAM obtained a PART 145 agreement in 2018 to maintain the components of these two STCs.

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| *FIG. 1. HELINUCTM system installed on AS 355.* | DSC_1949  *FIG. 2. HELINUCTM installed on EC 145.* |

## EXAMPLES OF AIRBORNE GAMMA MAPPING SURVEYS

During a flight mission, gamma detected by the HELINUCTM system come from:

* Natural radiation sources (cosmic rays, natural terrestrial radionuclides …);
* Industrial activities (phosphate processing, building materials, waste …);
* Radionuclide release of nuclear accidents : 137Cs in soil …

Recorded data are analysed to establish a radiological map over the topography of the surveyed area. The Fig. 3 below shows an example of a French zone surveyed: the gamma mapping represents the quantity of natural potassium 40K in Bq/kg. The lower quantity is located above the river, which contributes to attenuate the radioactivity. The higher quantity is located above a field and is due to the potassium contained in chemical fertilizers. In France, this radionuclide is naturally present in soil which must be taken into account when analysing data. Highest quantities are always compared to radiological background as shown in Fig. 4.

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| *FIG. 3. Gamma mapping of 40K in Bq/kg.* | *FIG. 4. Spectra containing high quantity of natural radionuclide (including 40K) compared to the radiological background of the surveyed zone.*  **Counts (c/s)**  Radiological background |

## CHALLENGES OF TRAINING HELINUCTM TEAM

The HELINUCTM team is composed of 15 persons and every day, three persons from CEA are on duty (24h/7d) and ready to operate in case of emergency in France. An average of 4 surveyed is done each year which are the opportunities to refresh knowledge of team members. Besides, each member must practice to be operational and trainings are numerous.

Every Monday morning, the on-call team tests and trains on material and software by:

* Attesting the presence of available material;
* Testing detectors, electronic bay, GPS and radio-altimeter;
* Training on software and recording data;
* Check data analysis and detectors’ performance;
* Train on standard practices (locking, wrenching, electrical bonding…).

Every action is recorded on a form and in case of any problem, a person in charge is available to solve it.

When new members are involved in the HELINUCTM team, 2 days of theoretical and on-site practical training are taught by one person in charge according to this plan:

* Review of HELINUCTM missions and organization;
* Use and practice on material (electronic bay, detectors);
* Use and practice on acquisition software;
* Installation and removal of material of the helicopter;
* Work and improvement in progress.

Besides, the following aerial theoretical units are taught for safety flying purpose:

* Aerial navigation authorities;
* Aeronautical documentation;
* Human factors (retraining every two years);
* Aerial circulation rules;
* Flight security;
* Locking, wrenching, electrical bonding.

Finally, each new member must participate on a real mission in the year to follow, during which they are taught about installation system documentations, qualification tests (stabilization, position), preparation of a flight plan, working system during a flight and data analysis.

Recurrent problems must be faced, as helicopter’s availability or flight authorization. Frequent trainings (one every year), both theoretical and practical contributes to an operational HELINUCTM team. Evaluation and feedback are always done to improve knowledge.

## CHALLENGES OF EXERCISES

The HELINUCTM team realizes two types of exercises with different goals: table-top exercises whose objective is to explain the planning of the HELINUCTM intervention in case of emergency and to estimate the intervention duration; and actual deployment exercises whose objective is to get real data by overflying a site and adding radioactive simulated data to the gamma mapping.

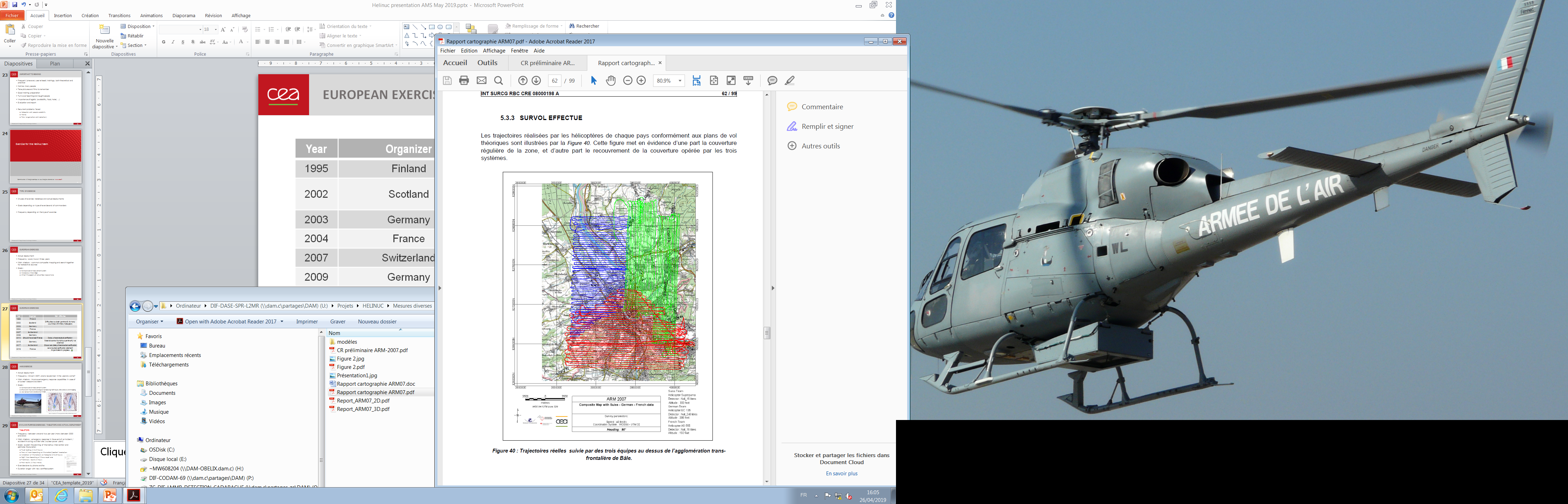
Table-top exercises are realized twice a year and are done by phone and fax. The HELINUCTM mission manager is joined and must evaluate the duration of the intervention, including the time of truck loading, time of travel, time of material installation, flight time, time before preliminary results and time before final results.

Different types of actual deployment exercises exist. Civilian purpose exercises consist in flying above civilian sites, as nuclear power plant as it can be seen on Fig. 5, to train in case of an emergency response in the event of an incident or accident involving a civilian site. Radioactive simulated data are inserted to real data to simulate the accident and gamma mapping as shown in Fig. 6 are obtained.

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| U:\Projets\HELINUC\Mesures EDF\Exercice INTRA EDF FARN 11 2018 Nogent sur Seine\PHOTOS\image1 (2).JPG  *FIG. 5. Picture taken during the flight of a French nuclear power plant.* | *FIG. 6. Map of gamma doses including real data obtained during the flight and simulated data obtained in case of radiological release.* |

Ministry of Defense purpose exercises consist in flying above French military site to train in case of an incident or an accident involving a military site. Goals are the same that the ones for civilian purposes but different radionuclides are searched.

Besides these exercises realized in France, the HELINUCTM team is engaged in a European collaboration. Every two or three years, European airborne gamma mapping systems gathered to realize a European exercise whose main goal is the attest the capacity of mutual help in case of crisis concerning a European country. As a nuclear crisis could happen in several countries or close to borders and extend on large surfaces, the cooperation between European teams is a necessity. During one week, airborne systems make a common composite mapping as shown in Fig. 7 and search together for hidden radioactive sources. By doing these collaborations, European countries also learn to know each other, compare their aerial measurement system and increase their knowledge on aerial gamma mapping system.



*FIG. 7. Common composite mapping made by the French, German and Swiss airborne teams above Bale in 2007[1].*

The HELINUCTM team has also a special relationship with the American airborne measurement system since the early 2000 and one common exercise had been organized in 2007 above the Nevada National Security Site (former Nevada Test Site) where American nuclear tests had been conducted for years. Moreover, Americans are organizing every year an international technical exchange on aerial measurement system where open and scientific discussions are conducted on a specific problem multiple teams face.

## CHALLENGES OF AN OPERATIONAL SYSTEM

## With the obtaining of two supplemental type certificates on two types of helicopter and the PART 145 agreement presented on Fig. 8, the HELINUCTM team must always be operational according to the aerial authority rules. Once the system has been used during a flight, it must be inspected and repaired respecting aeronautical documentation. Every system has its own requirement and documentation and every action done on the system must be written and analysed regarding the safety of the flight.

## These recent constraints have imposed a change in the way the system maintenance was done. All HELINUCTM members have been formed to aerial rules, double-checking and documentation. The system is now accessible to only few authorized people recognized by the European Aviation Safety Agency as it can be seen on Fig. 9. The CEA organization has to adapt to these new restrictions by staying operational at the same time.

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| *FIG. 8. Agreement certification obtained by the CEA to maintain its own aerial system.* | *FIG. 9. View of a closed zone accessible to only few people containing the HELINUC system.* |

## Every year, an inspector from the authority agency comes to check if all the regulations are correctly applied. The operability of the HELINUCTM system is nowadays dependent on the fully respect of aerial regulation in addition to nuclear rules.

## CONCLUSION

The HELINUCTM system is a complete operational aerial gamma mapping system developed for emergency response in nuclear security events. Developed in the early 80’s, the system can be deployed in few hours in France in case of crisis. Composed of CEA technical experts on call 24h/7d, it can be operated both for civilian and military purposes. The HELINUCTM system can also intervene under the command of national public authorities and international agencies (IAEA...).

Respecting aerial safety rules while installation and maintenance, it can be nowadays mounted on two types of helicopter. The system has operated more than 200 missions with more than 50 surveyed areas in France and numerous foreign deployments to ensure nuclear security.

References

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