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 HELINUC™ 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 HELINUC™ 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 HELINUC™ 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.

1. PRESENTATION OF THE HELINUC™ SYSTEM

The HELINUC™ 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. HELINUC™ 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 HELINUC™ 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 HELINUC™ 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 km^2/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.

FIG. 1. HELINUC™ system installed on AS 355.

FIG. 2. HELINUC™ installed on EC 145.

2. EXAMPLES OF AIRBORNE GAMMA MAPPING SURVEYS

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

— Natural radiation sources (cosmic rays, natural terrestrial radionuclides …);
— Industrial activities (phosphate processing, building materials, waste …);
— Radionuclide release of nuclear accidents : ^{137}Cs 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 ^{40}K 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*.

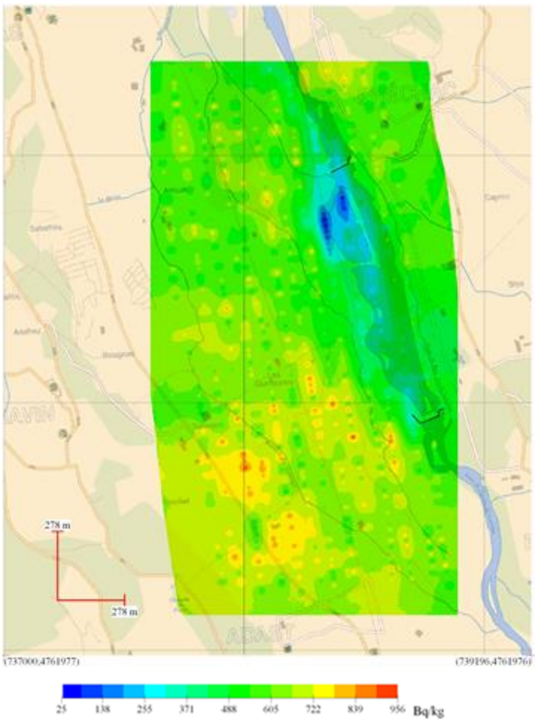


FIG. 3. Gamma mapping of ^{40}K in Bq/kg.

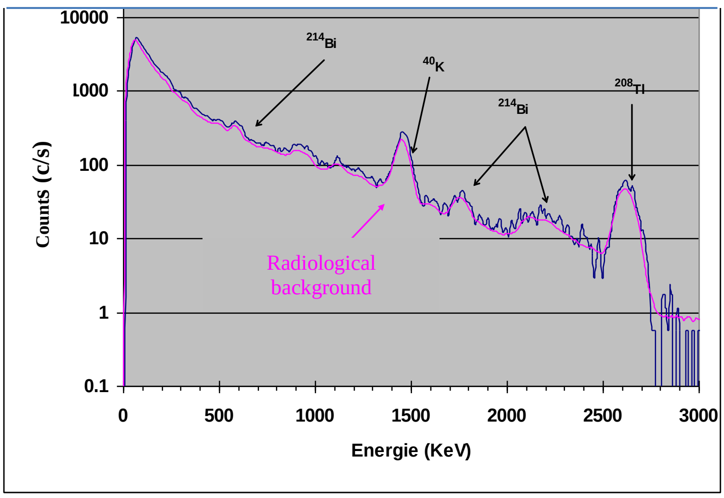


FIG. 4. Spectra containing high quantity of natural radionuclide (including ^{40}K) compared to the radiological background of the surveyed zone.

3. CHALLENGES OF TRAINING HELINUC™ TEAM

The HELINUC™ 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 HELINUC™ team, 2 days of theoretical and on-site practical training are taught by one person in charge according to this plan:

- Review of HELINUC™ 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 HELINUC™ team. Evaluation and feedback are always done to improve knowledge.

4. CHALLENGES OF EXERCISES

The HELINUC™ team realizes two types of exercises with different goals: table-top exercises whose objective is to explain the planning of the HELINUC™ 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 HELINUC™ 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.

FIG. 5. Picture taken during the flight of a French nuclear power plant.

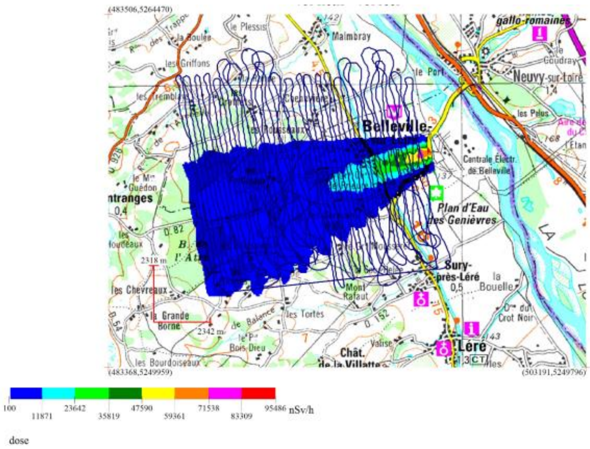


FIG. 6. Map of gamma doses including real data obtained during the flight and simulated data obtained in case of radiological release.

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 HELINUC™ 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.

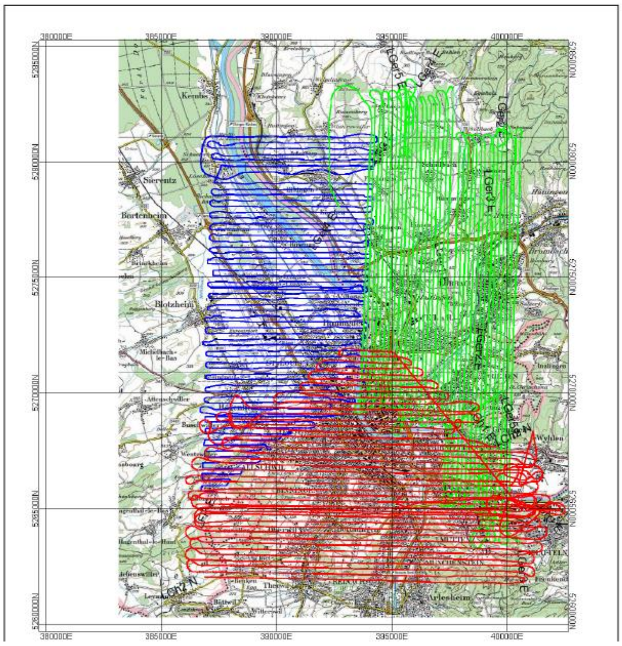


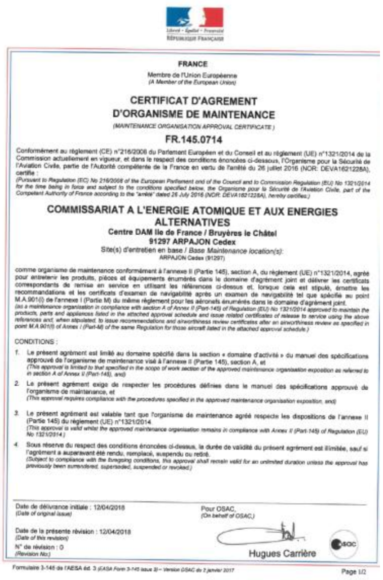
FIG. 7. Common composite mapping made by the French, German and Swiss airborne teams above Bale in 2007[1].

The HELINUC^{TM} 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.

5. 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 HELINUC^{TM} 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 HELINUC^{TM} 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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CERTIFICAT D'AGREMENT
D'ORGANISME DE MAINTENANCE
(MAINTENANCE ORGANISATION APPROVAL CERTIFICATE)

FR.145.0714

Conformément au règlement (CE) n°216/2008 du Parlement Européen et du Conseil et au règlement (UE) n°1321/2014 de la Commission actuellement en vigueur, et dans le respect des conditions énoncées ci-dessous, l'Organisme pour la Sécurité de l'Aviation Civile, partie de l'Autorité compétente de la France en vertu de l'arrêté du 26 juillet 2016 (NOR: DEVA1621228A), certifie :
(Pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council and to Commission Regulation (EU) No 1321/2014 for the time being in force and subject to the conditions specified below, the Organisme pour la Sécurité de l'Aviation Civile, part of the Competent Authority of France according to the "arrêté" dated 26 July 2016 (NOR: DEVA1621228A), hereby certifies:)

COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES
Centre DAM Ile de France / Bruyères le Châtel
91297 ARPAJON Cedex
Site(s) d'entretien en base / Base Maintenance location(s):
ARPAJON Cedex (91297)

comme organisme de maintenance conformément à l'annexe II (Partie 145), section A, du règlement (UE) n°1321/2014, agréé pour entretenir les produits, pièces et équipements énumérés dans le domaine d'agrément joint et délivrer les certificats correspondants de remise en service en utilisant les références ci-dessus et, lorsque cela est stipulé, émettre les recommandations et les certificats d'examen de navigabilité après un examen de navigabilité tel que spécifié au point M.A.901(l) de l'annexe I (Partie M) du même règlement pour les aéronefs énumérés dans le domaine d'agrément joint.
(as a maintenance organisation in compliance with section A of Annex II (Part-145) of Regulation (EU) No 1321/2014 approved to maintain the products, parts and appliances listed in the attached approval schedule and issue related certificates of release to service using the above references and, when stipulated, to issue recommendations and airworthiness review certificates after an airworthiness review as specified in point M.A.901(l) of Annex I (Part-M) of the same Regulation for those aircraft listed in the attached approval schedule.)

CONDITIONS :

1. Le présent agrément est limité au domaine spécifié dans la section « domaine d'activité » du manuel des spécifications approuvé de l'organisme de maintenance visé à l'annexe II (Partie 145), section A, et
(This approval is limited to that specified in the scope of work section of the approved maintenance organisation exposition as referred to in section A of Annex II (Part-145), and)
2. Le présent agrément exige de respecter les procédures définies dans le manuel des spécifications approuvé de l'organisme de maintenance, et
(This approval requires compliance with the procedures specified in the approved maintenance organisation exposition, and)
3. Le présent agrément est valable tant que l'organisme de maintenance agréé respecte les dispositions de l'annexe II (Partie 145) du règlement (UE) n°1321/2014.
(This approval is valid whilst the approved maintenance organisation remains in compliance with Annex II (Part-145) of Regulation (EU) No 1321/2014.)
4. Sous réserve du respect des conditions énoncées ci-dessus, la durée de validité du présent agrément est illimitée, sauf si l'agrément a auparavant été rendu, remplacé, suspendu ou retiré.
(Subject to compliance with the foregoing conditions, this approval shall remain valid for an unlimited duration unless the approval has previously been surrendered, superseded, suspended or revoked.)

Date de délivrance initiale : 12/04/2018
(Date of original issue)
Date de la présente révision : 12/04/2018
(Date of this revision)
N° de révision : 0
(Revision No:)

Pour OSAC,
(On behalf of OSAC,)
Hugues Carrière

Formulaire 3-145 de l'AESA éd. 3 (EASA Form 3-145 issue 3) – Version OSAC du 2 janvier 2017

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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 HELINUC^{TM} system is nowadays dependent on the fully respect of aerial regulation in addition to nuclear rules.

6. CONCLUSION

The HELINUC^{TM} 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 HELINUC^{TM} 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

[1] S. GUTIERREZ, “Compte rendu de la participation des moyens de mesure gamma mobile HELINUC, VLG et AUTONUC en Suisse au cours de l’exercice tri-national ARM-07 (Suisse, Allemagne et France) du 27 au 31 août 2007”, Communication privée.

[2] M. WANSEK, “Training and Exercises for aerial gamma measurements with HELINUC^{TM} system”, presented during 7th AMS International Technical Exchange, Las Vegas, 2019.