

The Use Of Laser For Bird Frightening

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Abstract

The French Technical Service for Air Navigation (STNA) is in charge of new bird scaring techniques against bird strike hazards. This paper summarizes all the researches completed in France since 1973 with light sources : on board aircraft flash lights, experiments with several laser sources, laser robot for the automatic protection of an airfield runway. Results are presented and discussed : bird species tested, range in relation with meteorological conditions, habituation, human, eye safety problem...

This paper will be presented by a 10 minutes video VHS.

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In the scope of measures against bird strike hazards, the French technical service for air navigation, STNA ("Service Technique de la Navigation Aérienne") is in charge of the development of new bird frightening techniques. The research approaches are based upon the sensorial organs which are the most developed in the bird: hearing and sight. So far, most of the frightening methods rely on acoustic stimuli (distress calls, disturbing signals, pyrotechnics means, ...). In continuous use, the fixed equipments which permanently play signals along the runways often generate noise nuisances for airport area residents. This is why the orientation of the research for replacement methods was naturally directed towards visual stimuli which do not create disturbances for the neighbouring populations. Amongst these methods, the use of light sources was considered very early on. The following article describes the non-exhaustive historical background of the research work already completed and gives an insight into the possibility of equipping the airfield runways with facilities based on automatic bird frightening by means of a laser source.

1973 The first bird frightening tests by means of a laser beam were carried out in the south-east of France by the STNA, with a continuous HeNe laser ($\lambda = 0.6 \mu$) of 6.4 mW power, lent by the Toulon naval dockyard authorities (DCAN (photo 1).

When approaching the laser beam, small birds of various species fly away to distances of 100 to 400 metres from the source. A captive pigeon avoids the beam by bending and turning its head. Herring gulls sometimes fly away during tests at the Aix-en-Provence garbage dump when the beam impact their eyes. Due to the beam's very small size, it is not possible to hit several individuals and induce a collective flying-off.

1976 Presentation of the results of bird frightening experiments by light sources, at the 11th Bird Strike Committee Europe meeting; tests carried out at the Marseille-Marignane airport by the STNA.

A condenser discharge light ($P = 2$ MW) focused by a mirror, induce a blue/violet flash and a deflagration, causes the flying-off of birds resting at 1 km from the source (photo 2). A laser prototype onboard an aircraft, intended to protect its front surface, is also studied but will remain at mock-up stage (Figure 1).

1979 A Swedish student, Karin Mossler, from the Stockholm physics institute, publishes a thesis titled "laser and symbolic light on birds in order to prevent bird/aircraft collisions". She demonstrates that:

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- the birds' retina is the most sensitive in the green or the blue/green spectrum (500 to 564 nm),
- the physiological response of the brain is better for exposures to red or magenta,
- the largest flying-off distance is achieved in the blue, then the red, the white and the green. To test these different colours, she used coloured papers waved at arms' length (wing flapping test) or light ramps imitating wing flapping,
- a continuous HeNe laser of 30 mW ($\lambda = 632 \text{ nm}$) causes the flying-off of sea gulls at rest on pisciculture basins, the results being all the more positive as the beam is concentrated. There is no habituation phenomenon.
- These results are comparable to those observed by Sheldon Lustick, obtained in 1973 at the Ohio University on Mallard ducks and sea gulls (evasive response without habituation, with concentrated beams).

1980 The STNA proposes a study of the long distance generation of a sound and light signal by means of a high energy laser. The principle consists in focusing at 500 metres from the source a pulse laser beam, and therefore inducing "an air bang" simultaneously with a light signal (plasma emission in the visible spectrum). These two stimuli are used in order to frighten birds. The practical problems of implementation, together with a tremendous cost and a "star war" aspect caused the study to be abandoned.

The STNA publishes the study of a flash light against bird/aircraft collisions, onboard an aircraft (study report No. 612 STNA/2N-01/87-BRIOT, EUDOT). This study clearly shows that a better signalling of the aircraft by means of very powerful onboard flash lights (photos 3 and 4) does not induce a more anticipated evasive response from birds in front of the aircraft which is flying towards them at a speed of approximately 120 kts. The flash light used has a luminance of 250,000 candela at 1 Hz.

1988-1990 Bird frightening tests performed with an HeNe laser gun of 5 to 10 mW power (photo 5). The initial bird frightening principle consists in impacting the bird's eye to cause flying-off. After multiple tests, it appears that the eye impact does not necessarily cause flying-off, but often an avoidance reaction by head movement. However, in favourable lighting conditions (twilight, mist, darkness, ...), a flying-off response is observed, when roughly aiming at the bird or the group of birds to be tested, whatever the species. The flying-off could have been caused by disturbance of the vigilance state necessary for the bird's safety. A first apprehension of what will later be called the "stick" effect is, however, felt: the flying-off could also be construed as the bird's fright due to the approach of a non identified intruder (in this case, the light beam materialised in air, and which has the appearance of a "stick"). Flying-off reactions were observed up to 300 m from the source.

1993 First contacts with the SYLAREC company. Several laser sources were tested :

- A continuous Argon laser emitting at 5 mW in the blue and green spectra,
- A continuous HeNe laser of 30 mW, emitting in the red (633 nm),
- A diode - pumped State (DPSS) YAG laser of 100 mW, (532 nm).
- A continuous CO2 laser of a few watts, emitting at 10,590 nm (thermal laser).
- A neodyme glass pulse laser, doubled in frequency, emitting at 530 nm (pulse duration of 26 ns).

These lasers are equipped with optical devices (afocal systems) which permit the diameter of the laser beam to be enlarged.

Multiple tests carried out on birds present on a garbage dump site allowed a high performance source to be selected: the DPSS (532 nm) YAG laser of 100 mW (photo 6). With this source, flying-off is obtained when approaching the enlarged beam: the "stick" effect is highlighted. However, these results are limited according to the ambient luminosity. The absence of the beam is felt, due to its small diameter, but the eye safety is not observed. The beam diameter is only 5 cm, in order to give a contrast which is sufficient to cause flying off.

1994 In order to maintain eye safety(*), a mock-up is developed, comprising a DPSS YAG laser of 200 mW (532 nm) and an afocal device permitting a 15 cm diameter beam to be created.

This system is mounted on a liquid head camera tripod, which easily allows the beam to be aimed at the targets (birds) to be tested. An S-VHS video camera collimated to the laser beam, enabled the experiments to be recorded.

Results are observed in various luminosity conditions and on various bird species (Lapwings, gulls, ducks, waders, starling, pigeons...). A flying-off response of the birds is obtained up to distances in the order of one kilometre, under lighting conditions of less than 13,000 lux, provided that the beam is kept in motion. No habituation to the moving signal is detected, even on nesting birds, although they are strongly attached to the nesting site (Saint-Yan experiment on crows).

(* Eye Safety

The main risk associated with the use of the laser is the risk of eye injury due to the strong surface power density likely to hit the retina. The eye safety limit is the limit power threshold receivable by the eye, beyond which there can be irreversible retina damage. With a laser source emitting in continuous mode at 532 nm, the maximal acceptable lighting is 25.5 W/m².

1995 Creation of an experimental laser robot mock-up for the automatic protection of an airfield runway (photo 7 and figure 2). The mock-up allows the automatic sweeping motion of a laser beam over a half circle. The robot can be adjusted so that the beam is plunging and plots a half-circle of an approximate radius of 1,000 m on the ground.

An astronomic telescope (Celestron) is used as afocal device to enlarge the laser beam to more than the admitted value, in order to obtain eye safety. The resulting beam has a diameter of 157.5 mm. The emission power is assessed at 146 Mw.

A first test campaign was conducted in the Veys Bay, using this mock-up. The results were quite disappointing. The birds only reacted to beam passage in very low lighting conditions (dawn and dusk). There was an obvious regression of the frightening power compared to the results obtained in 1994. After laboratory measurements, it appeared that the telescope used caused an excessive power loss in the output beam. On the one hand, a diagnosis showed that the laser power was reduced to only 100 mW (instead of the announced 200 mW), on the other hand, the central blanking of the telescope caused approximately 30 % of laser power losses at the device output.

1996 Further to observations made in 1995, it was decided that a 400 mW laser source would be used in order to compensate for the power loss in the optic equipment. This type of source was installed on the existing test mock-up. Eye safety at the system output was maintained.

A new test campaign was conducted in the Veys Bay. The automatic scanning of the bay caused flying-off when the birds saw the beam pass above or below them ($h < 2$ m), for luminosity levels up to 15,000 lux. However, it appeared that the surface covered, in terms of bird frightening, was limited by the impossibility of controlling the beam in elevation angle.

After this test campaign, the mock-up was installed on the Bretigny-sur-Orge military (CEV = In Flight Test Center) airfield platform, in order to detect the possible disturbance caused to the pilots or the various users of the platform, in the case of direct or reflective vision of the beam. Therefore, the system was mounted at 400 m laterally, to the South of runway 05/23, at approximately 1,100 m from the threshold 23.

After adjusting the beam and masking the critical zones, the various possible disturbance levels for the platform users (air traffic controllers, meteo operators, vehicles on the ground...) were cancelled.

Runs on the runway, during take-off and landing phases, or in level overflight at a height of a few metres, were performed with a light aircraft from the CEV. The system was either in automatic, or in manual operating mode. When in manual, the beam is fixed (spraying the runway threshold end) or follows the aircraft on its run. The pilot was not dazzled by the beam at any time. On the contrary, the pilot's attention can be diverted by lateral vision of the beam, when it is guided manually and follows

the aircraft. The pilot was sceptical as to the use of such a system in landing and take-off conditions in Category II or III. In fact, in such conditions, the pilot must keep watching the instruments and a possible diversion, even fleeting, is not permissible.

An inquiry was then conducted with the CEV pilots, whatever the aircraft used. The system was in operation during daytime flying hours. After three months of tests performed under various weather conditions (winter and spring 1997), no complaint was filed with the airfield's operations office, either by the pilots or by the other airfield users. No birdstrikes were registered during this period on this airfield except during the days when the laser was out of service.

Conclusion

The Bretigny experiment demonstrated the operational feasibility of an automatic airfield runway protection system against bird strikes by means of a laser device.

The next step consists in creating a pre-industrialisation prototype, whose scanning speed and beam routing would be programmable, in order to ensure the protection of the runway and surroundings, whatever the profile of the site to be covered. This prototype must be operational in an airport environment, without disturbing the existing installations, and in diversified weather conditions. A remote control and a monitoring function should enable the system to be started or shut down, and should allow the control of possible failures from the control tower or the ATC office.

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Abstrac 1

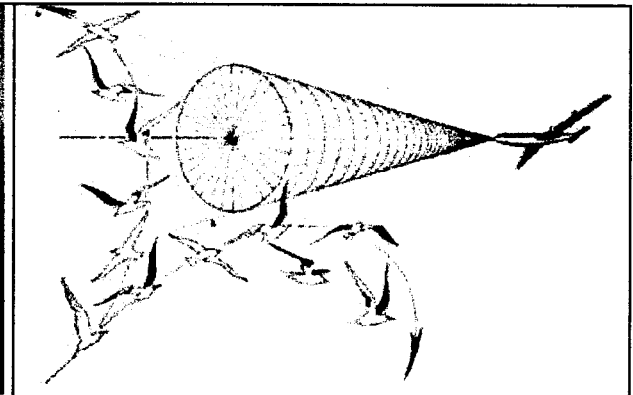


Fig 1

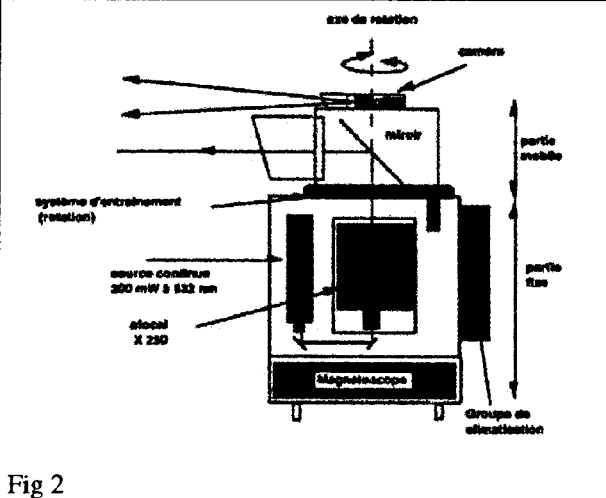


Fig 2

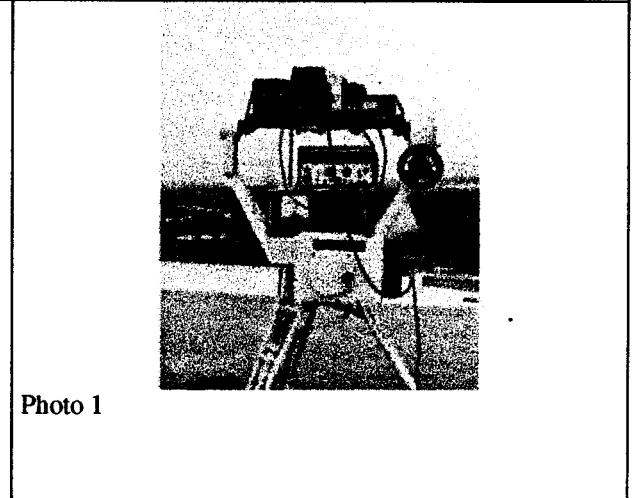


Photo 1



Photo 2

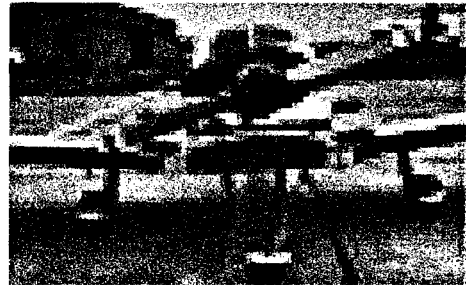


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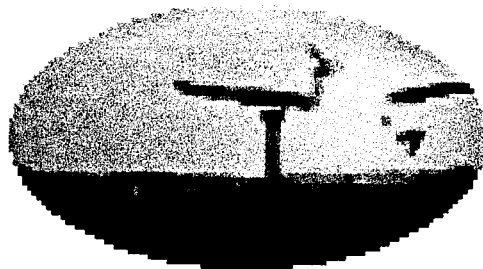


Photo 4



Photo 5

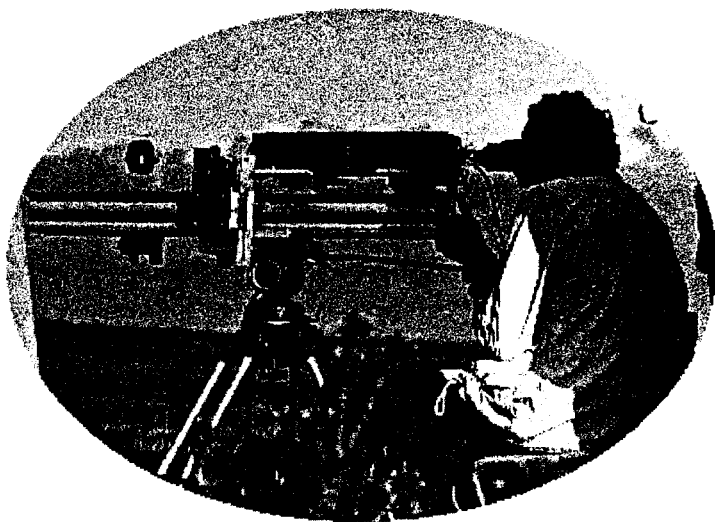


Photo 6

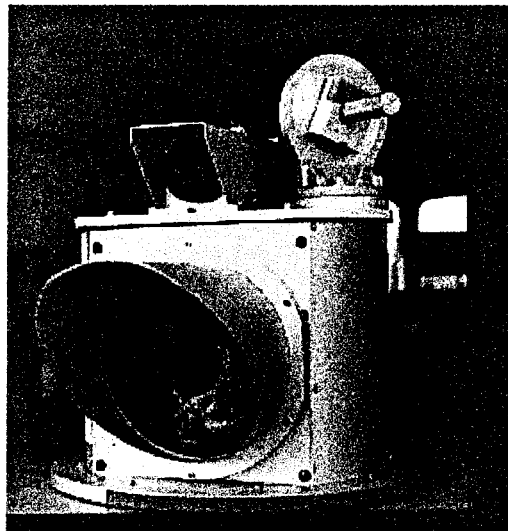


Photo 7