Sonic Boom: ISL studies from the 60's to the 70's

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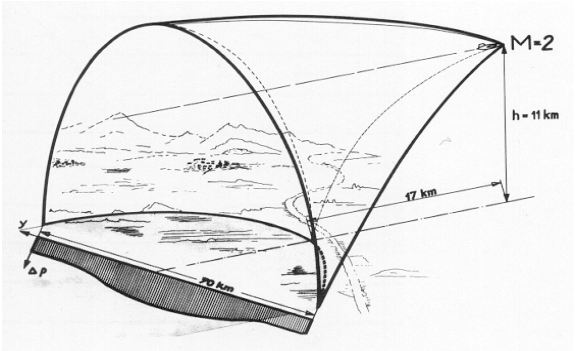
Introduction

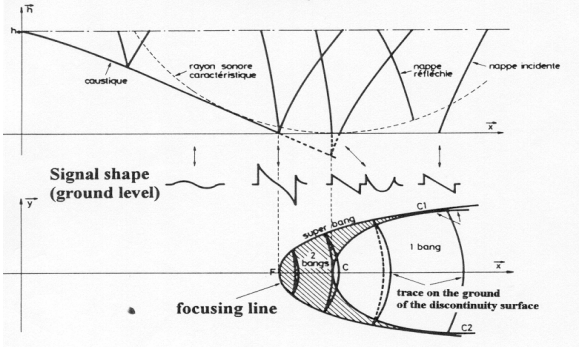
In the 60's, the sonic boom was responsible for many nuisances before the public opinion. The need for the military pilots to continue their training and the plans to build supersonic commercial aircrafts in the USA and in Europe (more specifically the British-French Concorde) made necessary to carry out comprehensive studies of the effects of the sonic boom on buildings, on animals and on man. In co-operation with many national and international organizations, the French-German Research Institute of Saint-Louis (ISL) played a leading part in that matter [1,2].

Physical measurements

The physical parameters of the sonic boom (N-wave) depend on the aircraft (duration: 70 ms for a fighter, 270 ms for the Concorde), on the flight conditions (altitude, speed, direction of flight, acceleration...), and on the meteorological conditions. The sonic boom carpet of a Concorde in stabilized flight (Mach 2) at 11,000 m is 70 km wide.



Accelerated flight and turns may induce focusing and a large increase of the peak pressure on limited areas. Meteorological conditions (temperature and wind gradients...) may greatly displace the carpet boundaries. Flight plans must take into account the actual meteorological conditions to minimize the impact of the sonic boom on the ground. Many theoretical calculations and field experiments have been performed by ISL to assess the propagation phenomena, the focusing effects and the vanishing contours (in co-operation with CEV, Istres; ONERA, Paris...).

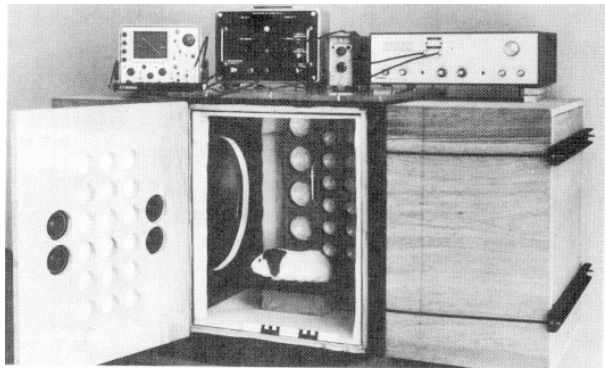


Propagation and focusing

Simulation

To study the effects of the sonic boom, it is possible to use the actual N-waves produced by military or commercial flights. In co-operation with the CEN (Grenoble) ISL participated in different campaigns to evaluate the risk of avalanche, the resistance of large window panels... . However, these campaigns do not allow to test systematically i.e., the behaviour of building materials and/or to determine the damage limits. Therefore, ISL developed three different simulation devices allowing to produce repeated sonic booms of peak pressures ranging from 10 to 5,000 Pa.

- a small acoustic room:

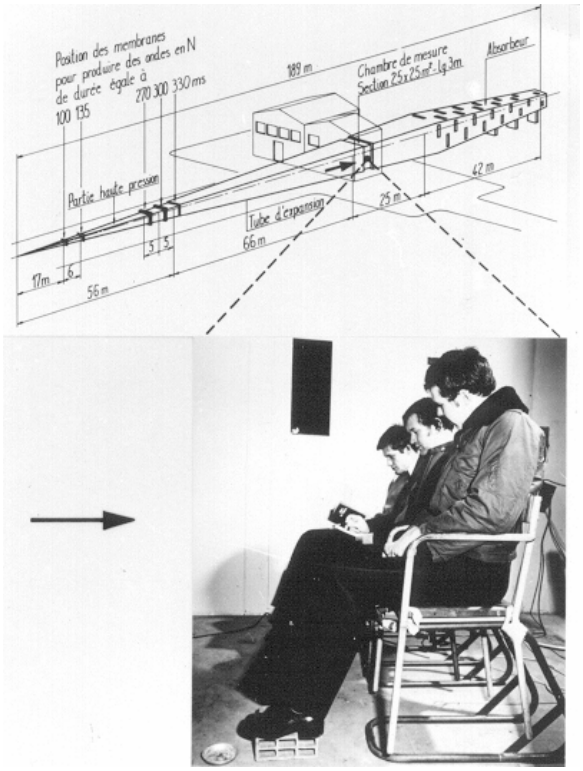


to test the behaviour of small animals and the response of panes,

- a mobile simulator:

made of two coupled shock-tubes to test the response of various wild and domestic animals (in co-operation with the SESSIA),

- a fixed generator: a large pyramidal shock tube (total length: 190 m) allowing to produce sonic booms of peak pressure up to 5,000 Pa (50 times larger than the normal level of the Concorde) and of total duration from 50 to 330 ms in a test room of 2.5x2.5x2.5 m was built on the testing range of ISL in Baldersheim.



ISL large sonic boom facility

Effects on building materials

Light panels of brick and/or plaster develop cracks following repeated exposures to 1,000 Pa (10 times larger than the normal level of the Concorde sonic boom). Cathedral glass may also be damaged by high level sonic booms. Old and/or poorly maintained building structures may suffer from repeated exposures to moderate level (in co-operation with the CSTB in Grenoble).

Effects on animals

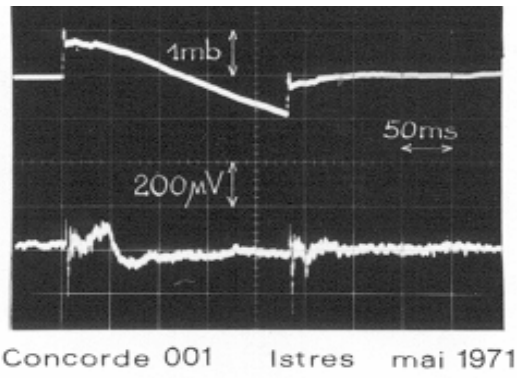
Effects on animals have been extensively studied. Results of French and more recent US studies relating to the behaviour of wild and domestic life: birds, horned cattle, horses, pigs, fishes... , the hatching rate of chicken and pheasant... , fail to demonstrate any significant damage or after effects. Results of studies relating to equilibration and hearing, electrophysiological [3], hormonal and cardiovascular responses... , indicate that normal sonic booms do not represent a risk for the wild life, the animals and/or for the animal productions.

Experimenters observed only short startle reactions which subsided quickly.

Effects on human beings

In co-operation with many national and international research institutes and universities, ISL performed a lot of studies relating to the effects of the sonic boom on man.

Influence on equilibration, on hearing, on the cardiovascular system, on sleep, on the performance, on the startle effect... was investigated.



Electrophysiological response of the guinea pig's cochlea

The conclusions of these studies are: the only noticeable effect of the sonic boom on man corresponds to the startle effect [4,5]. In most cases and for moderate levels (peak pressure: 100 Pa), this effect decreases when the subjects get accustomed to the N-wave. However, for some individuals the annoyance remains and/or eventually increases and may induce psycho-physiological disorders.

Conclusions

As corroborated by the Oklahoma City study [6], the main inconvenience produced by the sonic boom is the startle effect. Its importance is inversely proportional to the rise-time of the N-wave: for a given peak pressure the annoyance decreases rapidly with the rise-time. Acceptability of the exposure to sonic booms depends essentially on new technological advances allowing to attenuate the "pressure jumps" of the N-wave.

References

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