

THE CENTRAL SCIENCE LABORATORY BIRDSTRIKE RESEARCH CLUB

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ABSTRACT

- The Birdstrike Avoidance Team (BAT) (formerly the Aviation Bird Unit) of the Central Science Laboratory of the UK. Ministry of Agriculture has been at the forefront of research into the alleviation of birdstrike hazards to aircraft for over 20 years.
- In recent years the large scale research projects needed to further reduce the birdstrike hazard have become prohibitively expensive.
- CSL BAT has therefore established a subscription club designed to spread both the costs and benefits of birdstrike research as widely as possible.
- The CSL Birdstrike Research Club consists of a number of manufacturers, airport operators and regulatory authorities each contributing a relatively modest sum and benefiting from the results of a much larger research project.
- The first project carried out by the club is an evaluation of the physical properties of bird bodies and the structure of bird flocks in order to assist in the certification, design and testing of aircraft components world-wide.
- The research has involved the development of unique stereo video imaging techniques to measure the positions of birds in moving flocks and the use of Magnetic Resonance image scanning to model the internal structure of bird bodies. This project is endorsed by the Joint Aviation Authorities of the European Union, the US Federal Aviation Administration, the UK Civil Aviation Authority and the US Air Force.
- Membership of the Birdstrike Research Club is open to any funding organisation which wishes to participate. The club also invites proposals for future research projects. Projects involving collaboration with other research institutions, in Europe or elsewhere, would be especially welcome.

1. INTRODUCTION

The Birdstrike Avoidance Team (formerly the Aviation Bird Unit) of the Ministry of Agriculture's Central Science Laboratory has been involved in research into the birdstrike hazard to aircraft for over 20 years (Brough 1988). The data obtained from this work have been used in the development of many of the techniques currently used to reduce birdstrike frequency (e.g. Brough & Brigeman 1980). If research results are to be used to produce new guidelines or regulations for an such a large international industry, they must be both widely applicable and subject to scientific examination and validation. Research projects therefore need to be wide ranging, properly designed and analysed, and the data must be collected in a rigorous manner by trained scientists. Technological developments, whilst enabling scientists to investigate aspects of the hazard not previously open to study, often require expensive equipment and specialist support. Such studies are therefore expensive to carry out, and, during the recent recession which has hit the aviation community particularly hard, problems with the funding of research have become particularly acute.

If this large scale research designed to benefit the whole industry is to continue, and if the quality of the research is not to be sacrificed, some means of spreading the costs of projects needs to be developed. CSL has therefore established the **Birdstrike Research Club**.

2. THE CSL BIRDSTRIKE RESEARCH CLUB

The Birdstrike Research Club is constituted as an association of organisations, each subscribing an agreed sum to fund a specific research project. The work programme for the project and the subscription rates are agreed by the members on the basis of a simple majority vote. Participating organisations thus have the freedom to change research priorities subject to the agreement of their fellow investors, and are only committed to the club on an annual basis.

The funds are administered by CSL who are responsible for delivering the agreed research programme either by conducting the work directly or by collaborating with other research organisations. Validation of research quality, preparation of reports and dissemination of data to members are also the responsibility of CSL. Meetings of club members are held as required to assess progress and adjust work priorities as necessary. The data obtained remain the joint property of the members and will not be made available to other organisations except by agreement of all the participating organisations.

The arrangement outlined above provides investors with the opportunity to obtain research data from a large scale project, conducted to the highest scientific standards, at minimal cost. It also allows them to maintain control of the direction of the research programme and to evaluate the research output on a regular basis.

The first project being carried out by the club is described below. It is a large scale project, of general applicability to the industry, and involves international co-operation in the execution of the research .

3. THE BIOLOGICAL VALIDATION AND STANDARDISATION OF INTERNATIONAL BIRDSTRIKE TESTING TECHNIQUES

This project (described in detail by Allan & Hamershock (in press)) is designed to provide the aviation industry and regulatory authorities with biological information on bird body structure and bird behaviour. This information is needed both to validate existing tests used to proof aircraft systems against birdstrikes and to develop new testing techniques and certification requirements in the future. The project is currently supported by the UK Civil Aviation Authority, Rolls Royce, British Airports Authority, the US Air Force and British Aerospace; and is endorsed by the Joint Aviation Authority, the US Federal Aviation Administration and the UK Inspectorate of Flight Safety.

Plate 1. The volumetric tubes developed by US Dept. of Agriculture to measure the volume of bird bodies. Bird carcasses are placed in a metal cage and immersed in water. The displaced water is collected via an overflow spout and weighed to determine its volume



Photo: US Dept. of Agriculture

The research programme is being conducted in three phases, and involves collaboration with the US Department of Agriculture Denver Wildlife Research Station, US Air Force Wright Laboratories, and the University of Wales. A brief outline of the work in progress is given below.

3.1 THE PHYSICAL PROPERTIES OF BIRD BODIES

This section builds upon work completed by the US Department of Agriculture (USDA) which measured the body density of a number of commonly struck North American bird species (Hamershock et al. 1993). The objective of this phase of the study (carried out in collaboration with USDA) is to establish a world wide database of the body densities of those species regarded as the most hazardous to aircraft. These data will allow comparisons to be made between those species currently used in certification testing and those actually struck in operation. Data from the N. American species studied so far show significant differences between the domesticated chickens and ducks

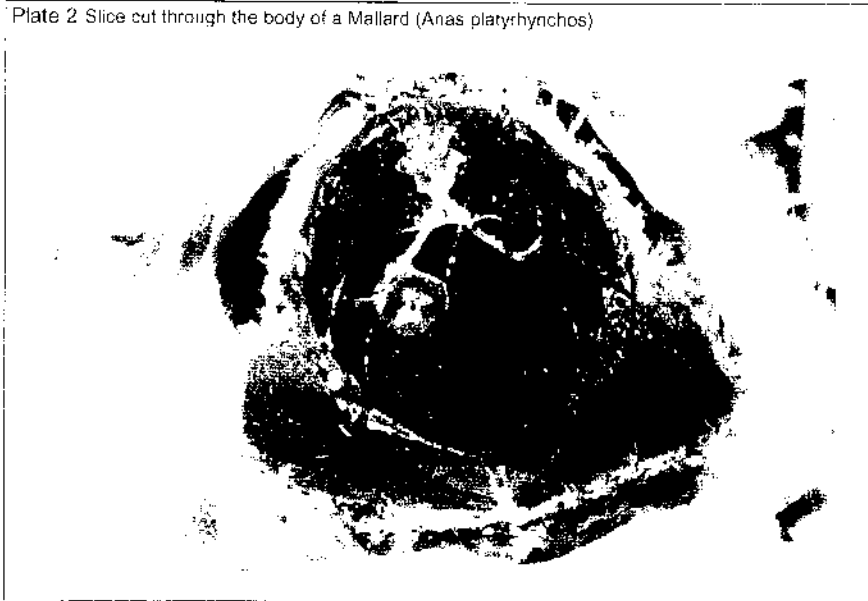
often used for testing and wild species (Hamershock et al. 1993).

The techniques employed are simple, involving the measurement of bird volume by displacement of water (see plate 1). Despite this apparently crude technique, the results obtained are remarkably accurate (data on repeat measures of single birds and measures of materials of known density both show consistent results). As well as density measurements, data are being gathered on the physical dimensions of bird bodies and the distribution of mass between the different body parts (head and neck, wings, legs, torso etc.). These data will assist in the choice of bird species to be used in real bird tests, and will aid the development of more realistic dummy birds for preliminary tests of aircraft components. Engineers and regulators are agreed that the selection of a standard species for real bird tests and the development of a more realistic dummy bird for use in development and testing are desirable to ensure uniform standards throughout the industry.

3.2 THE INTERNAL DISTRIBUTION OF DENSITY WITHIN BIRD BODIES

This section of the project is designed to provide information to the designers of aero-engines concerning the internal distribution of density within the bodies of birds. When a bird strikes a fan blade of an engine, the blade cuts a slice through the bird. It is the density and size of the slice, and hence its mass, that governs the damage done to the blade. Since the density of the different organs within a bird are

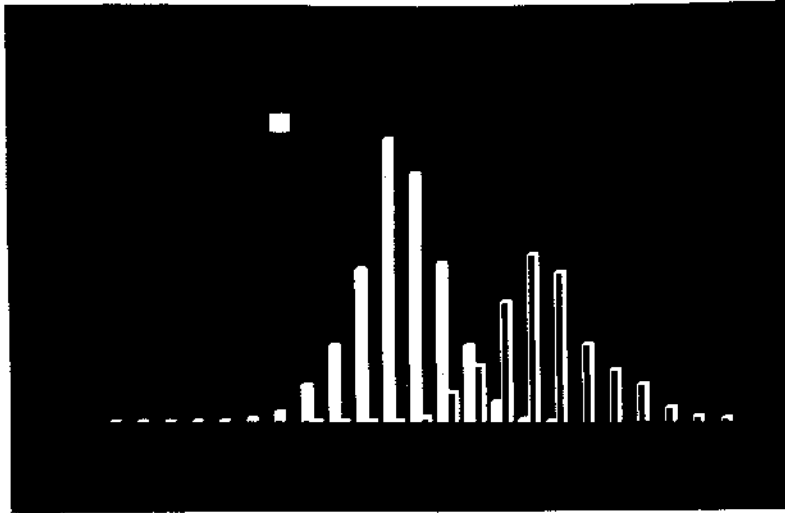
Plate 2 Slice cut through the body of a Mallard (*Anas platyrhynchos*)



different, the orientation at which the bird hits the blade (which governs the size of the slice), and the organs through which the slice is cut (which govern its density), will determine the slice mass.

In order to evaluate the slice masses likely to be cut through the bird species struck in operation at a variety of impact orientations, the bodies of birds are being scanned in a Magnetic Resonance Imager (MRI). The MRI produces a three-dimensional picture of the internal organs of the bird which can be fed into a computer model developed by the University of Wales. The model accepts density data (measured separately by displacement in water) for each of the organs and then computes the densities of slices cut by fan blades impacting the bird body at many thousands of different orientations (see fig 1).

Fig. 1 Distribution of slice densities modelled for two bird species the two distributions are statistically different (t-test, $P < 0.01$). (data used by permission of Rolls Royce Plc: values have been removed from the X axis to protect commercial confidentiality)



These data will help engineers to interpret the damage caused to blades during tests. They may also assist in the development of new dummy birds (the density of the dummy could be set to match the density of the worst case slice for example), and in the development of finite element modelling of impact events in the design process (at present 'birds' are modelled as uniform density cylinders with arbitrarily defined tissue strength).

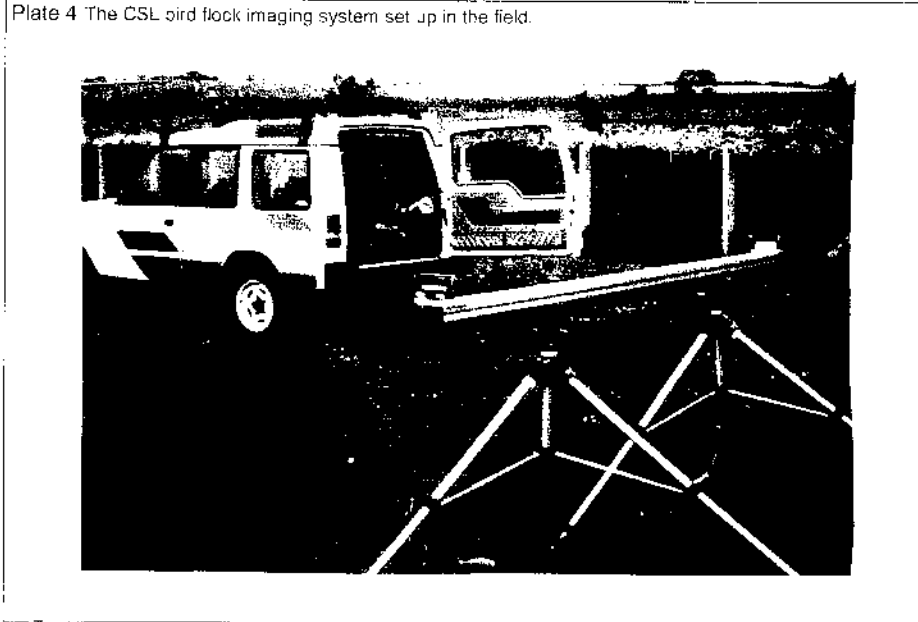
3.3 THE THREE-DIMENSIONAL STRUCTURE OF BIRD FLOCKS.

The final phase of the project has involved the use of CSL's unique bird flock imaging system. This portable imager is able to film flocks of birds and analyse the resulting videotape automatically to determine the position of each bird in space and to track that bird as the flock moves.

These data can be used to model the passage of aircraft, engines or other components through a flock and determine the probability of, for example, multiple ingestions into one engine, or simultaneous ingestions into more than one engine. These data can also be used to calculate the probability of multiple impacts to structures such as windshields, and to determine the time between such impacts.

The results will allow designers and regulatory authorities to base future decisions on certification testing requirements on independent biological data rather than relying solely on the in service record of existing aircraft.

Plate 4 The CSL bird flock imaging system set up in the field.



This project is currently in its first year of a scheduled three year programme.

CSL Birdstrike Research Club welcomes further investment from organisations who feel that they would benefit from participation in this project.

4. FUTURE STUDIES

Birdstrikes to aircraft continue to cause damage and delays costing many millions of dollars annually, although quantitative data on the true costs of birdstrikes to the industry are hard to obtain. Birdstrike related accidents involving loss of life occur regularly to military aircraft (Merrit & Dogan, 1992). Further fundamental research into alleviating the birdstrike hazard is clearly needed. Collaboratively funded projects, involving co-operation between research organisations, appear to offer a way of undertaking high quality research on subjects of general benefit to the industry at a modest cost to each individual funding organisation.

CSL Birdstrike Research Club would therefore welcome suggestions for future projects of general benefit to the aviation community, involving collaboration with other researchers either in Europe or elsewhere.

5. REFERENCES

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