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THE DEVELOPMENT OF A SUBSTITUTE ARTIFICIAL BIRD BY THE INTERNATIONAL BIRDSTRIKE RESEARCH GROUP FOR USE IN AIRCRAFT COMPONENT TESTING.

Richard Budgey
Birdstrike Avoidance Team, Central Science Laboratory, Sand Hutton,
York, YO41 1LZ, UK
Email: r.budgey@csl.gov.uk

Abstract

The use of artificial birds as substitutes for real bird bodies during aircraft component testing is becoming a more attractive option for aerospace companies. Using a standard artificial bird throughout the industry means that companies can operate in the confidence that their competitors are using a test of equal stringency. Other advantages arising from using artificial birds include convenience, cost, reproducible results and a reduced need to euthanase birds for tests.

Although many companies are already using artificial birds for pre-certification testing, they are rarely based on the physical properties of real birds. Although the function of an artificial bird is to reproduce the effects of an impact with a real bird rather than to copy the bird itself, basing the design upon real birds is the most logical starting point. The designs can then be validated in back to back tests with real birds.

The International Birdstrike Research Group (IBRG) is a consortium of aerospace companies and other aviation organisations comprising BAE SYSTEMS, the UK Civil Aviation Authority, General Electric Aircraft Engines, The Gas Turbine Research Establishment, India and Rolls-Royce Aerospace Group. The IBRG membership has funded measurement of the biometric properties of real birds and the development of artificial bird designs based on those properties.

Key Words: Testing - artificial birds, Aircraft components.

1. Introduction

One of the flight safety certificates required by aircraft components before they are allowed into operational use is a proven level of birdstrike resistance. To obtain the appropriate certification, a component must pass a series of bench tests - the item is mounted on a rig and struck by a bird fired at a realistic operational velocity from a high-powered gas cannon. An engine, for instance, must maintain a specified degree of performance after an impact with one or more birds of a specified mass. The number and size of birds depending on the size of the engine.

For final certification testing real birds must be used. Although the mass is specified, there is little standardisation throughout the world as to which species are used. Different species however, even of the same mass, have different physical properties.

Manufacturing organisations undertake a great deal of in-house testing prior to certification These tests are not subject to regulation and artificial projectiles are often used in place of real birds, although these substitute birds are not yet permitted in final testing. Again there is little standardisation throughout the world regarding the design of artificial projectiles.

1.1 Problems with using real birds

It has long been accepted that using real bird bodies in aircraft component testing is not ideal. The tests are not uniform. Because regulatory authorities define only the masses to be used, the species used vary. Differences in bird body density between species and even between individuals of the same species may cause different and unpredictable effects upon impact, with consequent implications for testing standardisation throughout the world. It is also difficult to ensure that the target point is struck properly because of the irregular shape of real birds.

Rearing birds for testing is expensive because the acceptable range of masses permitted for each test is narrow. Eliminating the need to euthanase animals for testing and to take animals from the wild are also worthy aims.

Substitute birds have been used widely in the aerospace industry to counter many of the problems described above. There has, however, been no increase in standardisation between organisations as each uses its own design of projectile. The designs are often based on the development of a convenient and simple testing procedure rather than on the biometric parameters of real birds and the tests may not therefore reflect the damage possible in a real birdstrike.

The International Birdstrike Research Group (IBRG) are a consortium of aerospace companies and regulators. The Group have developed a substitute bird design that is more representative of real birdstrikes because it is based on biometric data collected from real birds. Widespread adoption of an artificial bird such as this one will allow accurate, standardised testing both within and between different organisations.

2. Philosophy behind IBRG artificial bird design

The aim of birdstrike resistance certification testing is to ensure that aircraft and individual aircraft components are able to withstand an acceptable proportion of birdstrikes that are likely to be encountered in operation. The single test that is carried out for final testing is meant to represent all possible species that could be struck.

It may be argued that no artificial projectile can ever reproduce the complexities of a collision with a real bird and the very advantages that using artificial birds offer - standardised tests - also lead to a lessening of the accuracy and representativeness of the test. That is to suppose, however, that a test with a real bird is representative of anything other than a birdstrike with that particular bird. In reality a birdstrike can occur with almost any species of any sex, age or condition. To obtain a statistically valid picture of the effects of a collision using real bird bodies it would be necessary to repeat the test many times - a very expensive process, especially if one wanted to find out about a number of species.

The artificial bird designs developed by IBRG have all that repeat trialing built in - each projectile is a statistically accurate representation of the density, mass, size and shape of a particular species, or range of species. Biometric data has been obtained from a large range of commonly struck bird species, from House Sparrow (***Passer domestica***) at 30g to Mute Swan (***Cygnus olor***) at 8kg and a series of designs
developed that represent individual species or a range of species from the data set.

This data has been made available to the aerospace community, along with preferred IBRG designs for different testing situations. (See the IBRG artificial bird design proposals in Budgey et al , in prep) The user may determine which particular set of parameter values is the most appropriate for their test, or hopefully, a consensus will emerge across the industry as to which set will produce the most representative birdstrike test and all organisations will use that design.

3. The Design Process

The member organisations of IBRG listed which species were commonly struck according to their own databases. The top thirty or so of these were used as the basis for the IBRG artificial bird. Data were collected on density, mass, shape and size for normally ten individuals of each species and relationships identified across the entire species range between mass and density and mass and diameter. (See Seamans et al (1995) for a full description of the methods used for collecting biometric data.)

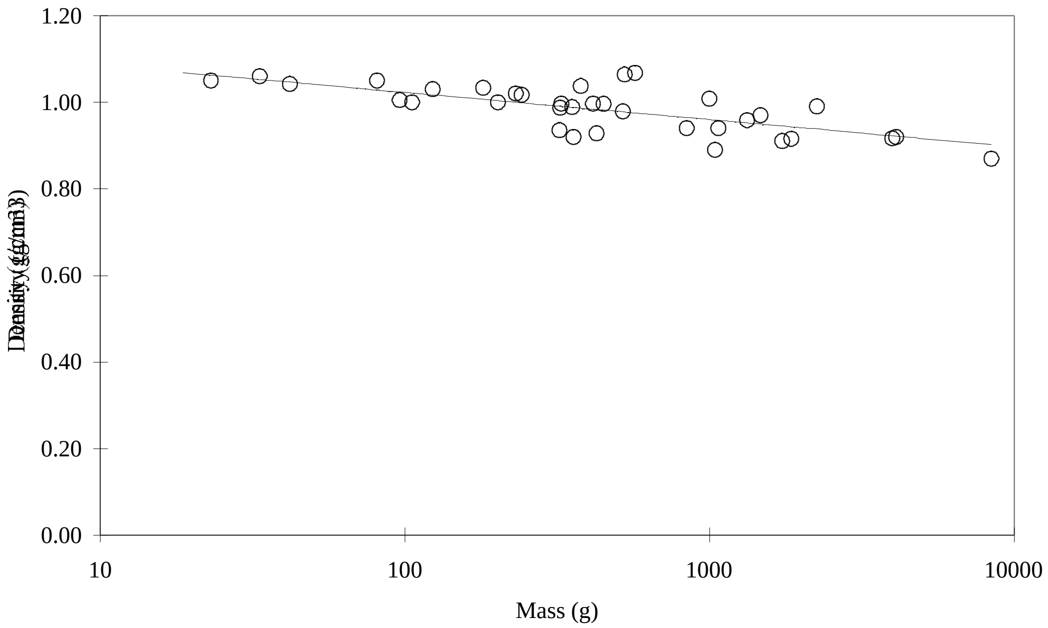
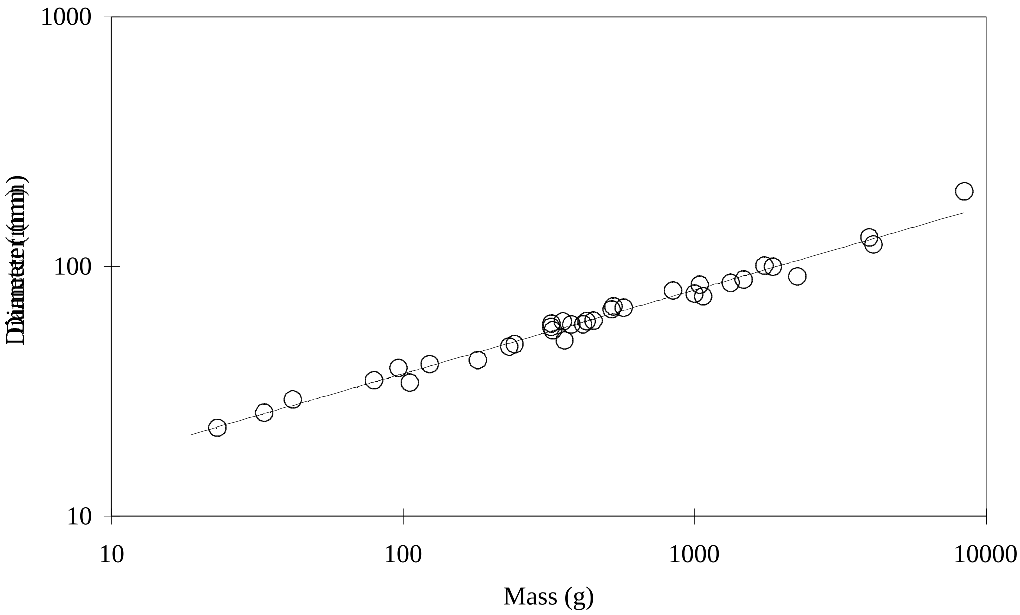


Figure 1. The relationship between bird mass and density for a range of commonly struck bird species. (The density is that of a bird with feathers removed.)

The formula for calculating bird density, from the regression line in figure 1 is:
Density = $-0.063 \times \log_{10}$ mass + 1.148

Thus, using this method for deriving a value of density for a given bird mass, the density of a 2.5lb projectile would be 0.96g/cm^3.

Figure 2. The relationship between bird mass and body diameter for a range of commonly struck species. (The diameter is that of a bird with feathers removed.)



The formula for calculating bird body diameter, from the regression line in figure 2 is:
Log_{10} diameter = 0.335 x $\log_{10}$ mass + 0.900

Thus, using this method for deriving a value of diameter for a bird of given mass, the diameter of a 2.5lb projectile would be 8.4cm.

In this way a projectile density and diameter can be calculated for any of the test masses stipulated by the regulatory authorities with values which represent all birds that are likely to be struck. Alternatively mean values for density and diameter can be taken from a subset of species that are close in mass to the current certification mass rather than from across the entire range, or even from a single commonly struck species with a mass close to the certification mass. The densest, 'worst-case' birds from this subset can be used as a basis for the artificial bird if it is preferred to have a more stringent test.

By looking at only those species in the IBRG data set with masses falling within an arbitrary range of +/- 25% of the regulatory certification mass, the density of the 2.5lb projectile would be 0.95g/cm^3 and the diameter would be 8.1cm. By comparison, the density of the Herring Gull, a species with a mass close to 2.5lb, is 0.89g/cm^3. The domestic chicken is often used in certification testing and is more dense at 1.04g/cm^3. The diameters of these two species are 8.5cm and 8.8cm respectively.

For some testing situations it may be appropriate to use an accurate value for the length of the projectile (impact time histories are important, for instance in an impact onto a flat panel) and the appropriate IBRG measurements can used in the design. Alternatively diameter may be the most critical parameter (for instance when testing the slicing effect of rotating aerofoils - here length is irrelevant so long as a slice of the required mass is achieved and an accurate diameter is therefore most important). A number of different shapes are suggested which permit the most appropriate values of mass, density, diameter and length to be used together in the same projectile.

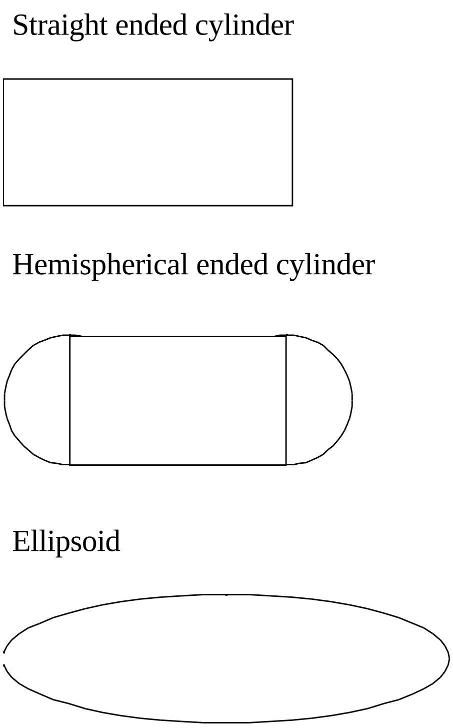


Figure 3. Three suggested artificial bird shapes shown to scale

4 The IBRG Designs

The full data set for the thirty four species measured by IBRG and the combinations of parameters recommended are too large to include in this paper. They are described in full in Budgey et al (in prep), which is available from the author.

5 Further Work.

5.1 Measurement of other biometric parameters

Other parameters not so far measured may be applied to an artificial bird design. IBRG intend to measure the 'toughness' or resistance to splitting of a range of species. This is considered to have an influence in certain impact situations such as the slicing effect of an engine fan blade of sharp leading edge (Edge & Degrieck 1999). The results of this work will be published as a further part of the IBRG artificial bird proposal.

5.2 Internal density variation

Internal density variation is normally ignored when designing artificial birds although it is considered when running computer simulations. There is no reason, however, why an artificial projectile should not more accurately mimic the internal density variation of a real bird if it is considered to be important and IBRG have already collected measurements on the densities of different bird tissues for a range of species.

5.3 Artificial bird manufacturing process

The IBRG artificial bird proposal does not include any manufacturing instructions, and again the processes used in the formulation of the projectile - usually made from gelatine, although not always - is an area where there is a lack of standardisation. A common manufacturing process and common materials should be adopted throughout the aerospace industry. The IBRG will produce a suggested manufacturing process in a further part of the IBRG artificial bird proposal.

5.4 Validation

The designs suggested here will require extensive validation through back to back testing, certainly before adoption in final certification testing. It is hoped that testing facilities will be made available by organisations interested in adopting a standardised birdstrike test.

6. Conclusion

It is hoped that a standardised artificial bird such as the IBRG bird will be adopted throughout the aerospace community so that birdstrike testing is as meaningful as possible. This is in the interest of those flying as well as those building aircraft as components throughout the world will be certified to the same standard.

7. Acknowledgements

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8. References

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