

Proposal AG24

Birdstrike Tolerant Structures

by

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## **GARTEUR AG24 Birdstrike Tolerant Structures**

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### **Main Aims of Research Programme**

- Round robin birdstrike modelling activities to determine SOA
- Design, fabricate, test and model a birdstrike tolerant structure
- Establish a standard birdstrike modelling methodology for certification



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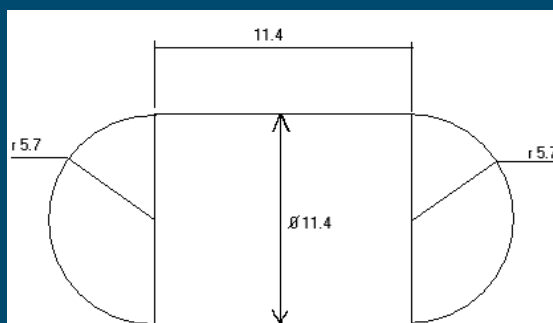
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## Achievements vs Aims

- Round robin exercises completed by one or more partners and comparisons made
- Birdstrike tolerant leading edge incorporating a novel tensor concept has been designed and tested
- Optimum birdstrike modelling methodologies have been identified depending upon the specific impact problem

## Round-Robin Exercises (1)

- Standard numerical bird parameters identified:
  - density, length, diameter and shape (dimensions in cm)

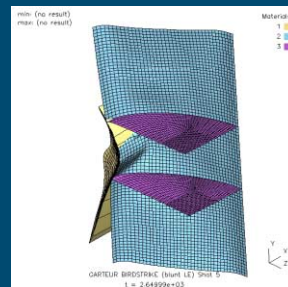
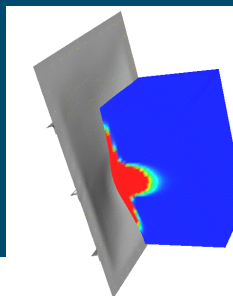


## Round-Robin Exercises (2)

- Material models used for the bird vary depending upon the FE code and modelling technique used:
  - Hydrodynamic bird model (10% air: 90% water)
  - Elastic-plastic bird model
- The target structure is equally important:
  - Sharp Leading edges split the bird deflecting energy away
  - Blunt leading edges suffer full bird impact

## Round-Robin Exercises (3)

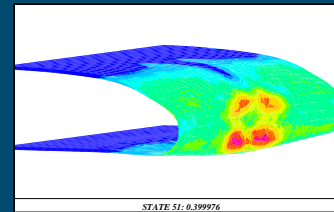
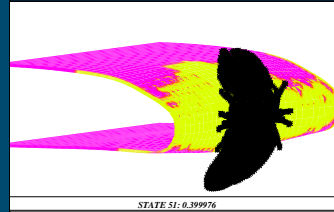
- Numerical modelling techniques investigated include:
  - Lagrangian whereby the FE mesh moves with the bird (LS-DYNA, PAM-CRASH)



Arbitrary Lagrangian-Eulerian (ALE) whereby the bird moves through the FE mesh (RADIOSS)

## Round-Robin Exercises (4)

- Smooth Particle Hydrodynamic (SPH) whereby the FE mesh is replaced by discrete interacting particles (PAM-SHOCK)
- Lagrangian methods tend to suffer from problems with mesh distortion in high deformation/flow regions of the bird so for bird splitting problems SPH methods offer a distinct advantage



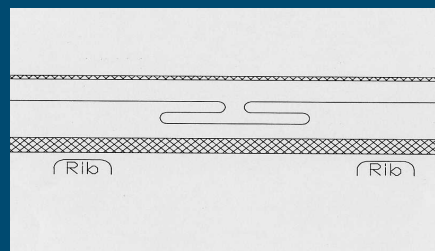
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## Novel Birdstrike Tolerant LE Design

- Novel Leading Edge design incorporates tensor concept which effectively traps bird



Glass cover face (woven aramid)  
 Folded Dyneema  
 UD carbon epoxy laminate



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## Birdstrike Test on Novel LE Design



- Impact velocity of 171m/s by a 4lb bird
- Bird penetrated LE, tensor deployed but did not contain the bird which broke front spar (impact velocity too severe)

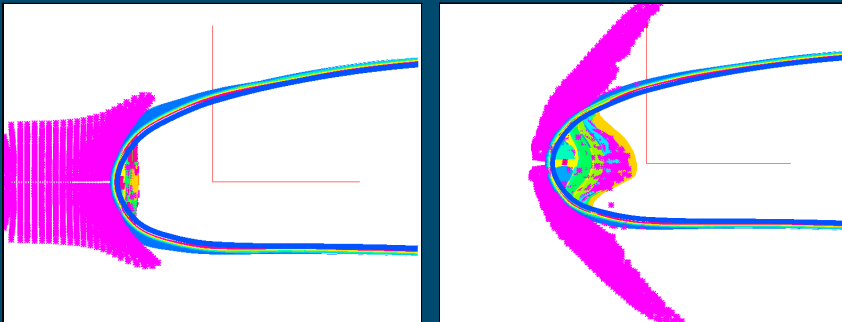


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## Modelling of Novel LE Design



- Shell FE model employing tied contacts which break on impact to represent unfolding of dyneema



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## Conclusions from Metallic Modelling Predictions

- CAA agree that substantiation of metallic structures using modelling techniques is now acceptable:
  - based on past similar designs that have been birdstrike tested
  - gap between old/new designs is widening as tools become more sophisticated
  - but limitations are evident & each simulation is judged on a case by case basis
- E.g. a metallic wing, tested at one weight, can incur a 30-40% weight increase & then be modelled rather than tested



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## Conclusions from Composite Modelling Predictions

- Main problem areas in modelling centre around having:
  - failure data suitable for input into FE models
  - improved progressive composite damage models
  - joints, discontinuities & various types of bonding
  - new materials (hybrids) requiring new material models & incorporation of complex structures
- Currently modelling of composite structures is used only as a first pass to determine design improvements
- It is the *structure* that is certified i.e. the material, manufacturing process and design



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## Acceptance of Modelling Predictions

- New radical designs, inc. metallic structures, will not be accepted on the basis of modelling predictions alone without having evaluated those predictions against some test data
- Currently most companies still undertake expensive experimental test programmes to certify new designs
- Modelling techniques, when used, are not as sophisticated as those presented by the GARTEUR group, rather they employ empirical data/analytical methods primarily to:
  - reduce the scope of testing
  - determine the effect of minor design changes

## Recommendations (1)

- Include preloaded structures: representing aircraft in flight
- Improve birdstrike tolerance by allowing controlled crushing of structural elements
- Stochastic modelling to represent e.g. manufacturing defects
- Scope widened to include e.g. hail, lightening, concrete, bulk heads, wheel rims, rubber, etc.
- Scaling of impacts: manufacturers want to test higher impact weights at lower impact velocities (proof that straightforward scaling does not work)

## Recommendations (2)

- Development of a synthetic bird:
  - Huge variations in impacting bird cause even more variation in damage to structure (which creates major problems with modelling predictions)
  - Bird composed of e.g. gelatine/sawdust, agar/oil-filled microspheres (International Birdstrike Research Group remit)
  - Must generate *at least as much* damage as a real bird
  - Allow easier comparison with numerical modelling predictions and between tests