**Institution: Coventry University**

**Unit of Assessment: 15**

**Title of case study: Improving Passive Safety in Crashes**

## 1. Summary of the impact

This case study describes the international impact of research in the computer modelling and simulation of automotive and aerospace crashes, undertaken by Professor **Blundell**. The main impacts arising from the research can be summarised as:

**Economic impact and impact on passenger safety:** i) our research has led to improvements in the MADYMO software suite, the 'industry standard' software for safety design and virtual crash testing, which is produced by TNO Automotive Safety Solutions (TASS) and sold to all the main equipment manufacturers in the automotive and aerospace sectors ii) our research has reduced the costs of these equipment manufacturers, who can simulate a crash rather than undertake expensive, physical, crash tests iii) by improving MADYMO, our research has had an impact on passengers who are now travelling in cars and aircraft which safer as a result of MADYNO's enhanced capabilities.

**Impact on practitioners and professional services**: through working with **Blundell** and his group, Autoflug GmbH has learned how to incorporate advanced simulation into its product development process. The work has also transferred practices from the automotive sector into aviation. **Blundell**'s research has helped to introduce manufacturers and European regulators to new methods to design safety systems to helicopters, an area previously underdeveloped as an area in aviation occupant crash protection.

**Beneficiaries** include Autoflug GmbH, TASS and its customers, and European aviation regulators.

## 2. Underpinning research

The underpinning research in automotive and aerospace safety described in this case study has been undertaken by Professor **Blundell** and colleagues over the last 15 years, much of it in collaboration with a number of industrial partners. This included major programmes of research [1,3] in vehicle dynamics and safety coordinated by Professor **Blundell**. The research has been diverse in application and sector but has had a common theme of developing, validating and assessing the effectiveness of computer simulation for engineering design in vehicle dynamics and crash safety. It has included work on pedestrian impact, vehicle roll-over, airbag deployment, adaptable vehicle structures and human body modelling.

A particular highlight of **Blundell**'s work has been the €4.8M EU FP6 project HeliSafe TA (Helicopter Occupant Safety Technology Application), which ran from 2003 to 2007. The project researched the simulation of helicopter crashes, which often kill occupants who would have survived automotive accidents of similar severity. The project had 12 partners from 7 countries, and the computer simulations developed at Coventry University informed the requirements for an extensive range of helicopter crash tests performed in Germany, Spain and Italy. During the project, **Blundell** and his team worked with project partners TASS to develop their industry standard MADYMO software, used globally by the automotive and aerospace industries to simulate crashes and improve occupant crash protection. In addition to helicopter safety, areas of application of the work with TASS includes projects addressing vehicle rollover, adaptable car structures for occupant crash protection, pedestrian impact, human body modelling and the simulation of airbag deployment.

The simulation methodologies used throughout this work were multi-body dynamics, finite element methods or a combination of both. **Blundell**'s ability to bring transferable automotive knowledge and capability to the project was an important contributor to the success of Helisafe. The main focus of the project was to design for post-crash risks including those associated with rollover on ground impact, operation over open water, or operation in remote areas where rescue may be delayed. In all cases, it was important to develop solutions that would mitigate occupant injury and enable them to leave the helicopter after a crash. The attention throughout was on the interior of the cockpit and cabin, with the particular focus on improving seats and harnesses, and for the first time to consider and evaluate the use of automotive airbag technology in a civilian helicopter.

The Helisafe test programme used three crash test dummies representing the pilot, a forward facing passenger and a side seated passenger. Full-scale computer models of the helicopter were developed, including representations of: a) the interior of the cockpit and cabin areas, b) all three occupants and c) the new safety concepts. Non-destructive sled testing was performed using

structural mock-ups for the pilot dummy and cockpit area at Siemens in Germany, and for the passengers and cabin area at CIDAUT in Spain, before final full scale crash tests were performed at the Italian Aerospace Research Centre (CIRA). 'Before' and 'after' tests were performed at all three sites to evaluate the performance of the new safety concepts developed during the project. The computer generated outputs from **Blundell** were used to select the best harness designs and specify the pre-loads and firing times for the harness belt-pretensioners. The positioning and firing time for the airbag was specified using the outputs from **Blundell**'s simulations. The full scale computer model and interior computer model with occupants are shown in Figure 1. The crash test dummies and crash structure are shown in Figure 2.

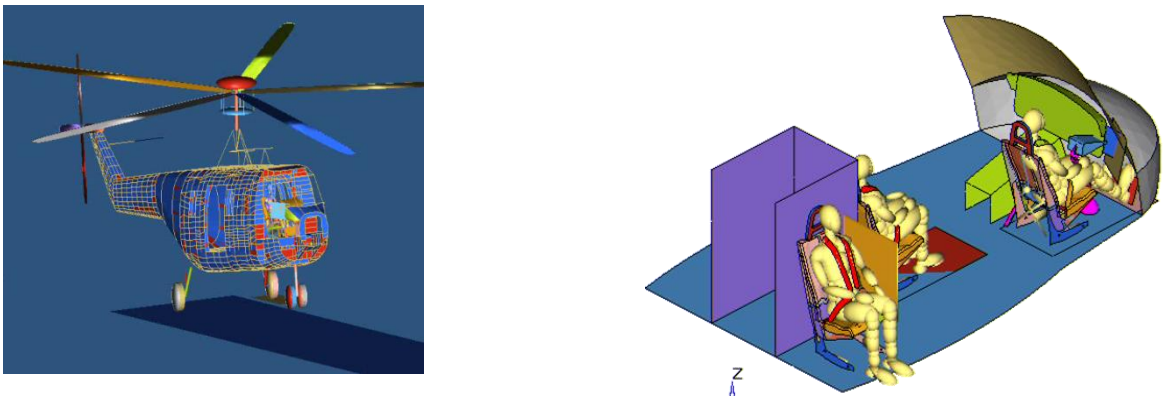


Figure 1 Coventry University Helicopter and Occupant Computer Models

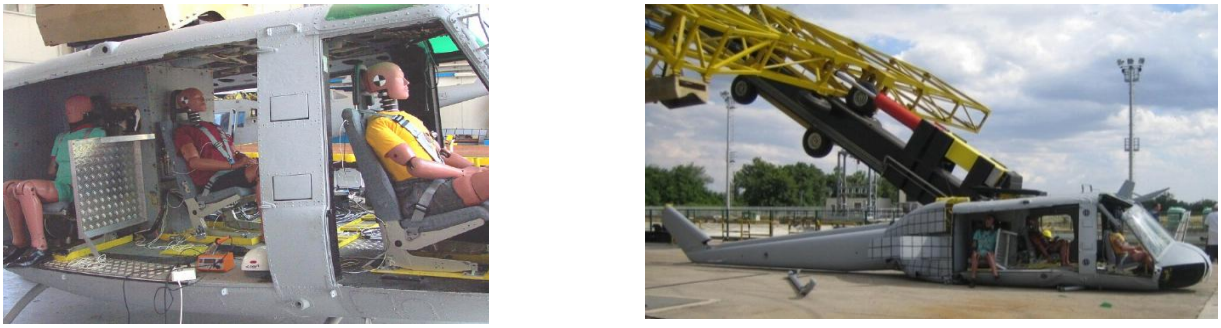

Figure 2 Helisafe Crash Test Dummies and Helicopter Crash Structure

The computer simulation work by **Blundell** was the first successful modelling of helicopter rollover. It demonstrated computer simulation [4] to develop, test and evaluate an occupant protection programme in the aerospace sector by transferring methodologies from the automotive sector.

## 3. References to the research

1) Leglatin N., **Blundell**, M.V., & Blount, G.N. (2006). The simulation of pedestrian impact with a combined multibody finite elements system model. *Journal of Engineering Design, 17* (5), 463-477
2) Mahangare, M., Trepess, D., **Blundell**, M., Freisinger, M., Hoffmann, J., Smith, S.J. (2006) A methodology for the simulation of out-of-position driver airbag deployment. *International Journal of Crashworthiness*, 11 (6), 511-517.
3) Ramamurthy, P., **Blundell**, M.V, Bastien C., Zhang, Y. (2011) Computer simulation of real-world vehicle-pedestrian impacts. *International Journal of Crashworthiness*,16 (4), 352-363.
4) Vadlamudi, S., **Blundell**, M., Zhang, Y. (2011) A multi-body systems approach to simulate helicopter occupant protection systems. *International Journal of Crashworthiness*, 16 (2), 207-218

**Key Research Funding**

- European Commission 6th Framework Programme for Research,Technological Development and Demonstration - Helisafe TA (AST3-CT-2004-502727), €4.8M 2003-2007.

## 4. Details of the impact

The main impacts have been economic, on the safety of automotive and aerospace travellers, and on practitioners and professional services. There has been additional impact on society, culture and creativity.

**Economic and safety impacts**: There have been two strands to the economic and safety impacts of this research:

- First, **Blundell**'s research has contributed to the development of the TASS' MADYMO suite of software products, which is sold globally throughout the automotive and aerospace sectors. According to van der Made, who was Engineering Manager at TASS from 2005 to 2007, **Blundell** contributed significantly to developing the MADYMO software in three main areas: airbag simulations, automotive safety and human modelling, with airbag simulation being having the greatest impact. His research helped to inform the development of software for crash testing when a passenger in a vehicle is 'out of position' and 'to implement real improvements', this being 'one of TASS' best-selling global products'. van der Made explained that **Blundell** developed knowledge and models of application of the MADYMO software, which includes how to use the software in different areas (e.g. automotive, aviation). It is this application knowledge, according to van der Made, which is the added value to TASS and allows them to market and sell better the software, and to guide its future developments [a,b].
  **Blundell**'s research has had an impact on the safety of automotive and aerospace travellers globally. This is a result of his research leading to significant improvements in TASS' MADYMO software, which is used to improve travellers' safety, and which TASS supplies to all the main equipment and vehicle manufacturers in the automotive and aerospace sector.
- Secondly, the improvements made to the software enable equipment manufacturers who purchase it to simulate many different crash scenarios. Undertaking many real-world crash tests would be prohibitively expensive. For example, it is a requirement that before being approved for use, a new aircraft seat design must be subjected to a crash test, which can cost up to €30k: simulations do not remove the need for a real crash test, but they do enable the manufacturer to test many different seat designs and save significant sums of money by only crash testing the final, software-optimised design. Furthermore, safety regulations require the certification of each layout of seats in an aircraft, and the use of testing according to the industry standard 'head injury criterion' test. By using MADYMO, the Brazilian aircraft manufacturer, Embraer, was able to experiment with several seat configurations on its aircraft, without the need for costly testing of each configuration. This enabled it to increase the customisation of its aircraft, so providing aircraft more precisely suited to the needs of its airline customers which is given it a competitive advantage over companies not using MADYMO. Embraer have estimated that using software simulation saves it an estimated £300k per seat layout [c].

**Impacts on practitioners and professional services**: Edgar Uhl of Autoflug GmbH has stated that working with **Blundell** and his team on the HeliSafe project has taught Autoflug how to incorporate simulation into the product development process. The benefit to Autoflug is that computer simulation now provides a method for obtaining workable solutions which directly supports new product design. He has said that this is now used in at least 20% of Autoflug's aircraft seating product range and has been of real benefit to the company, which turns over approximately €18-20M p.a. [d]. As stated previously, the helicopter sector is characterised by much lower safety levels than the automotive sector. **Blundell**'s work with helicopter and safety equipment manufacturers has resulted in the transfer of robust and established automotive design and development practices, such as safety harnesses and airbags, into aviation. In addition, **Blundell**'s research has been widely disseminated to practitioners working in the field, contributing to debate about 'best practice' in automotive and aerospace safety. For example, in 2011, **Blundell**'s group presented their work on the use of topology optimisation in lightweight vehicle architectures at the 2011 Altair Technology Conference attended by representatives of the automotive industry including more than 500 engineers and simulation experts from 25 countries. In 2012, the group presented at the ICRASH 2012 conference, and more recently at an international symposium on 'Human Modelling and Simulation in Automotive Engineering'.

It has been long recognised by the sector that helicopter crash survival lags considerably behind automotive. **Blundell**'s work on the HeliSafe project has led directly to the availability to practitioners of design tools to improve passenger safety systems for the helicopter sector. His work with on the project with Autoflug GmbH to develop and test the prototype of a safety harness project demonstrated, according to Uhl (Scientific Coordinator at Autoflug) an improvement in occupant protection of between 20% and 40% across the evaluated injury criteria [e].

The HeliSafe project has informed the policy debate on aviation safety at the European Aviation

Safety Agency, EASA, the sector's hugely influential regulatory and policy-making body. The lead partner in the HeliSafe consortium, Autoflug, was invited to present the results of the research at EASA's rulemaking workshop in 2008 and 2009. Due to the interest in the project findings, EASA asked for information from the project, and copies of videos of crash tests undertaken as part of HeliSafe, which EASA used in a film on "Certification and Standardisation". In 2009 Autoflug was invited to become a member of the European Helicopter Safety Analysis Team (EHSAT), which is the working group of the EHEST (European Helicopter Safety Team) and Autoflug contributed to the analysis work and proposed the utilization of the HeliSafe Safety Concept through this group. This work is ongoing [f].

A summary of the Helisafe project is available in the project's final publishable activity report [g].

**Impact on society**

To enhance public interest and engagement in science and engineering, and to stimulate public discourse, some of the work described in this case study has been disseminated in the wider media and press. Most notably:

i. Television broadcast on the German-Swiss-Austrian TV-channel '3sat' on the 7th and 8th July 2005 for the daily science-programme "Nano".
ii. Television broadcast on Deutsche Welle TV worldwide in August 2005.
iii. Television broadcast on the daily science program "Daily Planet" on Discovery Channel Canada. The programme was transmitted on 17th January 2008.

**Conclusion**

**Blundell** and colleagues have worked with industrial collaborators over many years to increase the survivability of a crash. Their work with TASS to improve the MADYMO software has brought significant economic benefit to TASS, but also to TASS' customers who are now able to simulate crashes rather than undertake real, physical tests. **Blundell** has had strong impact too on professionals working in Autoflug GmbH, taking advanced simulation techniques from academia into SMEs.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

a) Robin van der Made, Product Manager, TASS (information collected by RAND Europe in an interview, see report PR-536-CU)
b) Testimonial from TASS
c) Aircraft Interiors International, September 2009, p58ff. PDF copy held by Coventry University.
d) Edgar Uhl, Scientific Coordinator, Autoflug GmbH (information collected by RAND Europe in an interview, see report PR-536-CU)
e) Testimonial from Autoflug GmbH
f) Consideration of the Helisafe work for European policy can be evidenced by samples of non-confidential emails between the Helisafe Coordinator and EASA, available on request from Coventry University.
g) A final publishable activity report (AST3-CT-2004-502727) is available for the Helisafe project from Coventry University.