WORKSHOP

"**Modern challenges for understanding and protecting against lightning phenomena**".
15 July 2019, Advanced Manufacturing Building, Jubilee Campus, University of Nottingham

Workshop Objectives:
The objectives of the workshop include the creation of a high profile critical mass of researchers and technologists to promote and attract funding for all aspects of lightning technology.

The specific objectives of the workshop are:

- To create a new multidisciplinary research community in lightning technology research, by developing interaction between the research community and appropriate science, technology and industrial groups;
- To define immediate research challenges;
- To shape future research directions in lightning protection for avionics, power generation and transportation industry, and
- To initiate specific projects for which funding will be sought.

Workshop	Notes	Lead(s)
Workshop session: Identify a number of relevant topics	Following introductory remarks by Prof Ana Vukovic and Chris C Jones, workshop delegates identified four priority topics to explore more fully during the workshop. These are: - Threats - Next Generation Systems and Systems Integration - Electrical Wiring Integration System - Computability and Validation	Ana Vukovic, Chris Jones and Franck Flourens
Workshop session: Report from the groups and round table discussion on each of the priority research topics	**Topic: Threats** The group looking at Threats reported the following; 1. Analyse and collate available data sets of natural lightning strikes 2. Identify shortfalls and propose programmes to mitigate the lack of data 3. Evaluate the appropriate threats for next generation military and civil manned and unmanned air vehicles 4. Evaluate appropriate threats for ground-based systems 5. Study the evolution of a lightning channel and its interaction with conductive objects 6. Evaluate the interaction with airflow for initial and subsequent (swept) attachments	Richard Crook Paul Stocking David Riordan Alastair Ruddle David Dewhurst

	7. Evaluate the means and relative contributions to the internal environment in a structure resulting from lightning strike	
	Topic: Next Generation Systems and Systems Integration - Current funded projects include those motor insulation system and solid state circuit protection, but they do not include lightning protection - Look at the overall protection system – combine arc tracing with lightning protection in one system - Development of Solid State Circuit Breaker for arc protection, short circuit protection and lightning protection. - Power electronics designs need to be hardened for lightning threat – distribution and integration of power electronics is a mitigation factor - Simulation/validation tools – different methods for different purposes; from circuit analysis for full wave modelling. - Special focus on cable coming into contact with composite part – this is a weak contact and the current can penetrate into the composite layers. Need multi-physics modelling. - Need to investigate how much current can carbon accept (which is not recognised) and also how to design/modify electrical characteristic of carbon (conductivity) to get better electrical properties. Also how conductivity deteriorates in carbon. - System integration – we need to investigate do we need to integrate the whole system or can carbon be used to manage short circuit and lightning protection. - Next generation will use circuits embedded into the structure- to make it insensitive to lightning threat	Franck Flourens Richard Ovenden Ana Vukovic Pat Wheeler
	Topic: Electrical Wiring Interconnecting System (EWIS) Direct/Indirect - Do the standards need to change? - All electric, higher/new voltage levels - Transfer function review (coupling between objects)– simulation methods - Wide separation? - Software/modelling tools development needed - Depends strongly on type of the aircraft – part electric, all electric, UAV, tilt rotor, helicopter- - Harness/cable current capacities - Standard test with which CEM needs to agree - Make the science work for engineering	Ian Attoe Trevor Benson Stephen Boag Christopher Emersic David J Grant Paul Wallace Simon Earl

	- Distributed black box issues - Funding Strategy – how to work together (need to bring in manufacturers) - New wiring technology – materials, construction - New wire design – lighter, more current capacity - Data sharing is needed - Connectors – backshells, bonding and grounding of shields	

	Topic: Computability and Validation
	- What are we simulating?
	- Do we have enough information on:
	  ▪ Material parameters
	  ▪ Governing equations
	  ▪ Geometry detail
	- Reduction of complexity – model based, geometry based; different levels of modelling for better understanding
	- Managing uncertainty – determinate processes, statistical phenomena
	- Economics
	- Is our approach valid – proof, what is the error, are approaches statistical or deterministic
	- Multiphysics – coupled/decoupled
	- Multiscale – geometrical/temporal
		Manu Haddad
		Christian Karch
		Dan Morgan
		Mark Panitz
		Phillip Sewell
		Nigel Westmoreland

Workshop session: Identifying specific proposals and actions	**Specific Proposals and Actions:** - EPSRC Network Grant - Widen network to include: Leonardo (Yeovil), Saab, RWE, BAE Maritime, Met Office, University of Reading, Vesta, Innovate UK, ATI, National Grid, Network Rail, Mobile Networks - Map areas of expertise - Identify steering group members - Circulate note of workshop and presentations	Ana Vukovic and Trevor Benson (EPSRC network grant) Chris Jones (BAE Maritime contact), David J Grant (Vesta), Tanja (IUK, ATI) Ana Vukovic Ana Vukovic, Chris Jones, Trevor Benson Tanja Siggs

Based on group reports Prof Chris Jones has summarised topics that need to be expanded into credible research projects. These are:

Lightning Threats:

1. A practical means of measuring lightning strike threats to aircraft or other objects incorporating cable systems, that could be used to gather real lightning threat data.
2. Regional variations in lightning threats.
3. The effects of structural features in the internal electromagnetic environment within a structure when struck by lightning.

Next Generation Systems and System Integration:

4. Power and fault current implications for CFC airframe structural design.
5. Effects of joint conductivity on the Electromagnetic environment inside a CFC or hybrid CFC/metal structure struck by lightning.

EWIS:

6. Investigation of the means for defining Electromagnetic coupling levels into large, unstructured, multi-cable bundles arising from Lightning strikes.
7. Cable bundle design optimisations for maximum shielding effectiveness at minimum cost.

Computability and Validation:

8. The relationship between complexity and accuracy in computational electromagnetics.
9. The effects of parametric uncertainties (range of values) in CEM.
10. Design and evaluation of validation cases for CEM solvers and solver systems.