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FAULT DETECTION OF ELECTRICAL SYSTEMS TOWARDS VALIDATION OF SIMULATION DATA

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Abstract. *This paper presents a Fault Detection tool based on Artificial Neural Networks (ANN) as it was developed and implemented for the validation and verification towards certification from simulation of aircraft electrical networks. Furthermore, this fault detection tool was designed and implemented via the internet utilizing online collaboration platforms and purpose-designed automated interfaces. The main goal is for the Fault Detection tool to be able to independently verify and validate the ability of the global aircraft electrical network to simulate faults correctly, as required by certification authorities, since it comprises of numerous sub-networks and components designed by third-party suppliers.*

1. INTRODUCTION

Full-scale test rigs are used to Validate and Verify the integration of aircraft systems, including the energy systems, which supply the physical implementation of all systems, and, consequently, which may impact all aircraft functions. Such tests arrive late in the development process and the objective of this test case is to enable running similar test activities based on modeling and simulation using BDA capabilities, for identifying and solving integration issues earlier, but also up to the certification phase to save time and reduce costs in this intensive programme activity. Electrical systems are tested for faults during the prototype development and validation phases on physical test-rigs. The process, apart from being costly and time-consuming, limits the advantages of electrical systems development through simulation. In order to validate that the BDA is fit for validation activities for energy models, a fault detection and prediction model has been developed and applied. This is based on Artificial Neural Networks and detects the location of specific faults defined as well as predict the locations of faults about to be induced by the electrical system.

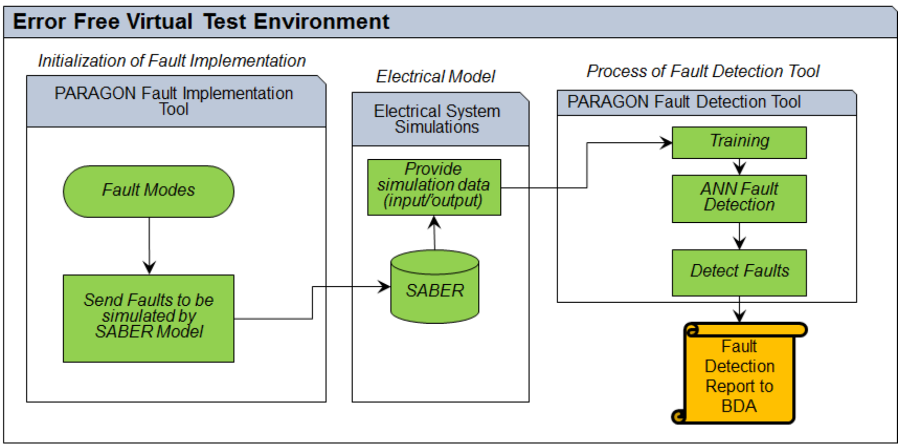

Fig.1: Fault Detection Process Diagram

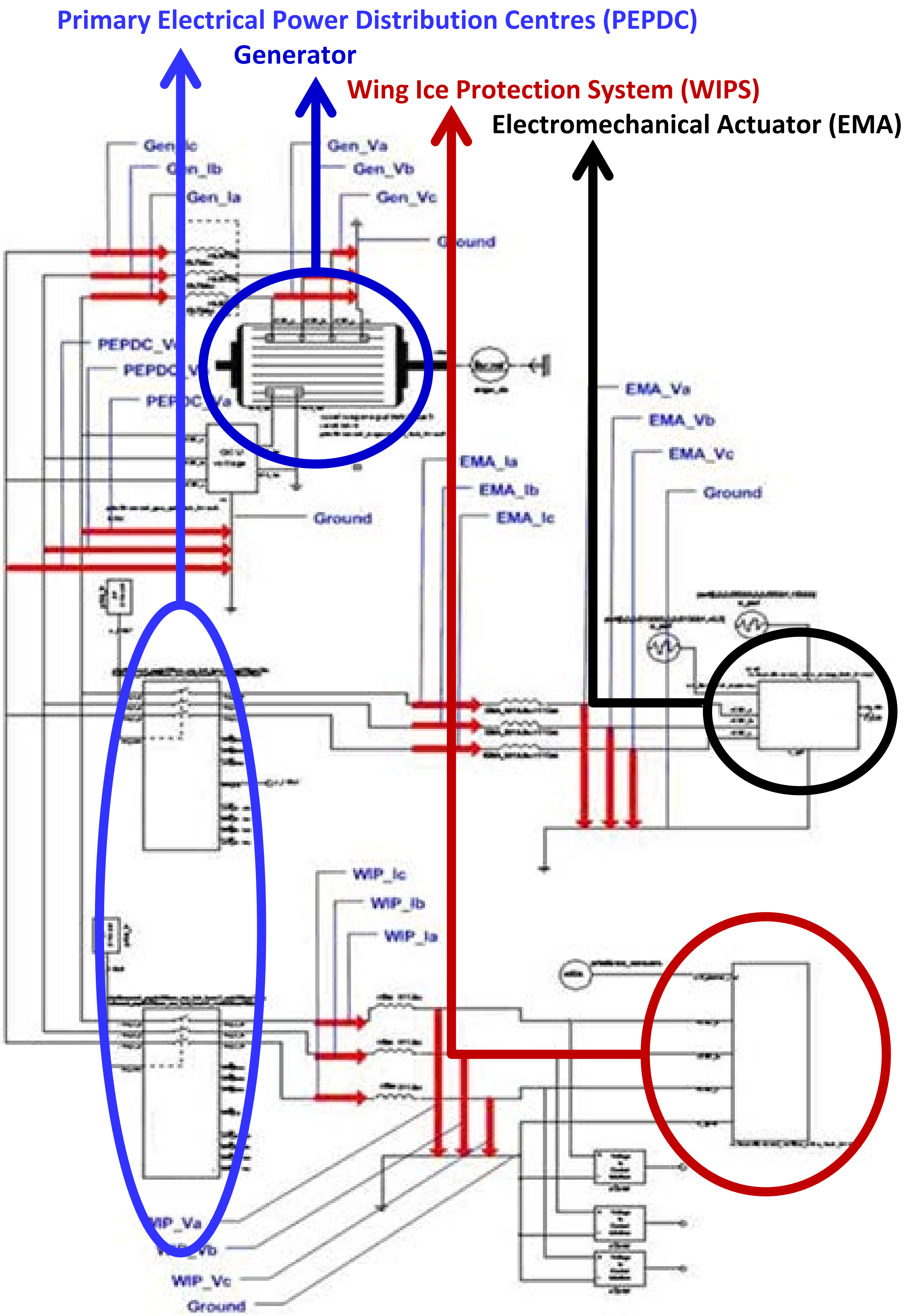

Fig.2: Electrical System Layout

2. FAULT DETECTION MODEL

The objectives of this model are to reduce component/systems rework and the necessity for physical testing. A solution is provided by utilizing other simulation data from an electrical network with components such as: a variable frequency starter generator, an electromechanical actuator, a wing-ice protection system and primary electrical power distribution centers. The concept behind the development of the fault detection tool is explained and demonstrated with the help of the simulation data, along with its results.

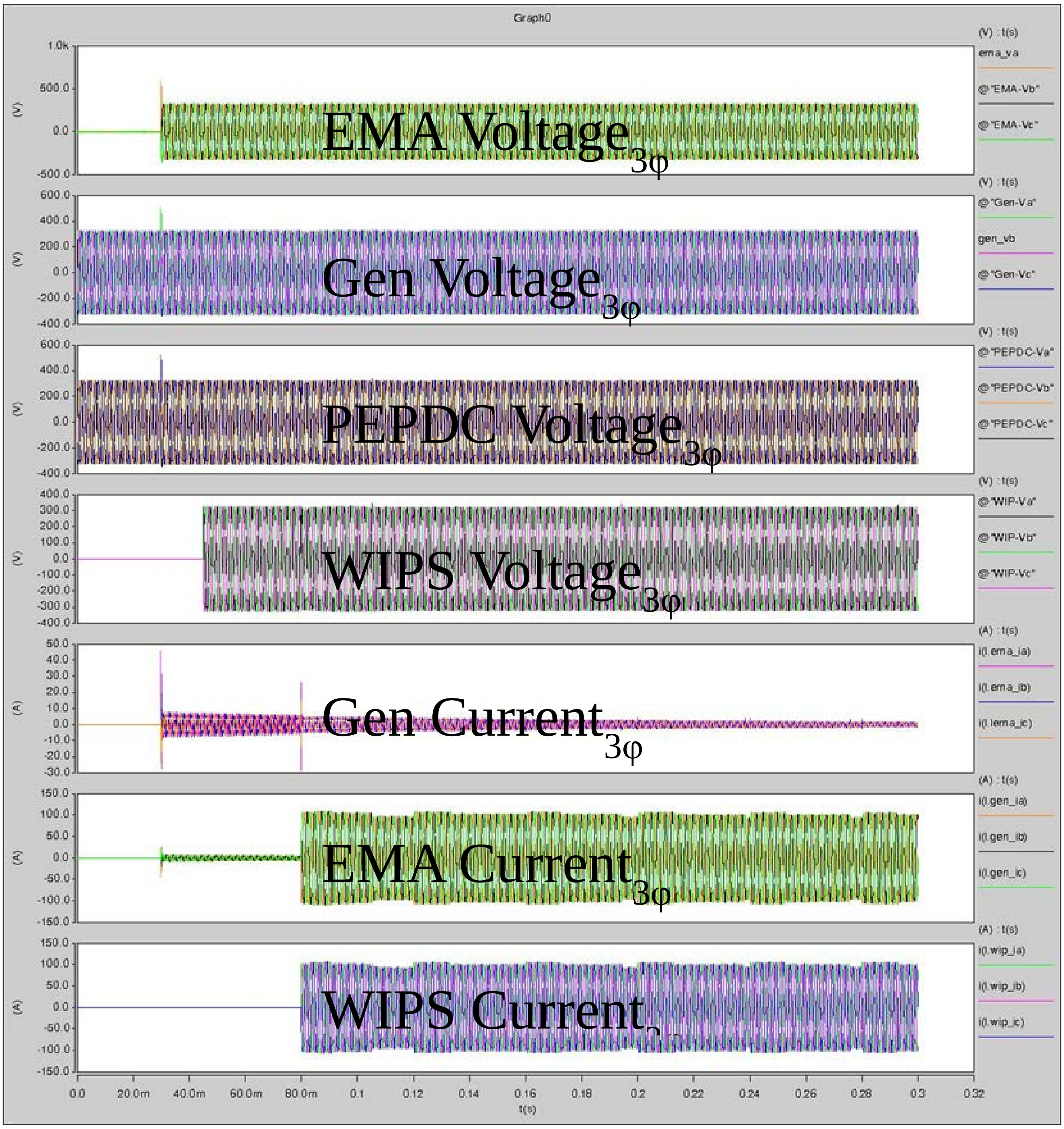

Fig.3a: Normal Simulation Data

2.1 Artificial Neural Networks (ANN)

The ANN model for electrical system fault detection & prediction is developed in C++ (some modules are developed in Matlab) using data sets of electrical systems simulations for operation under specific faults and normal operational conditions.

The faults to be simulated depend on the available systems' topologies, but typically involve time-series of

voltage and current from component locations of the electrical network under varying conditions (normal operation with inrush currents under different loading conditions, single and multiple short-circuits, etc.).
The data sets are pre-processed in preparation for being input to the model. The majority of the data sets are used to train the model while the rest is used to validate its performance.

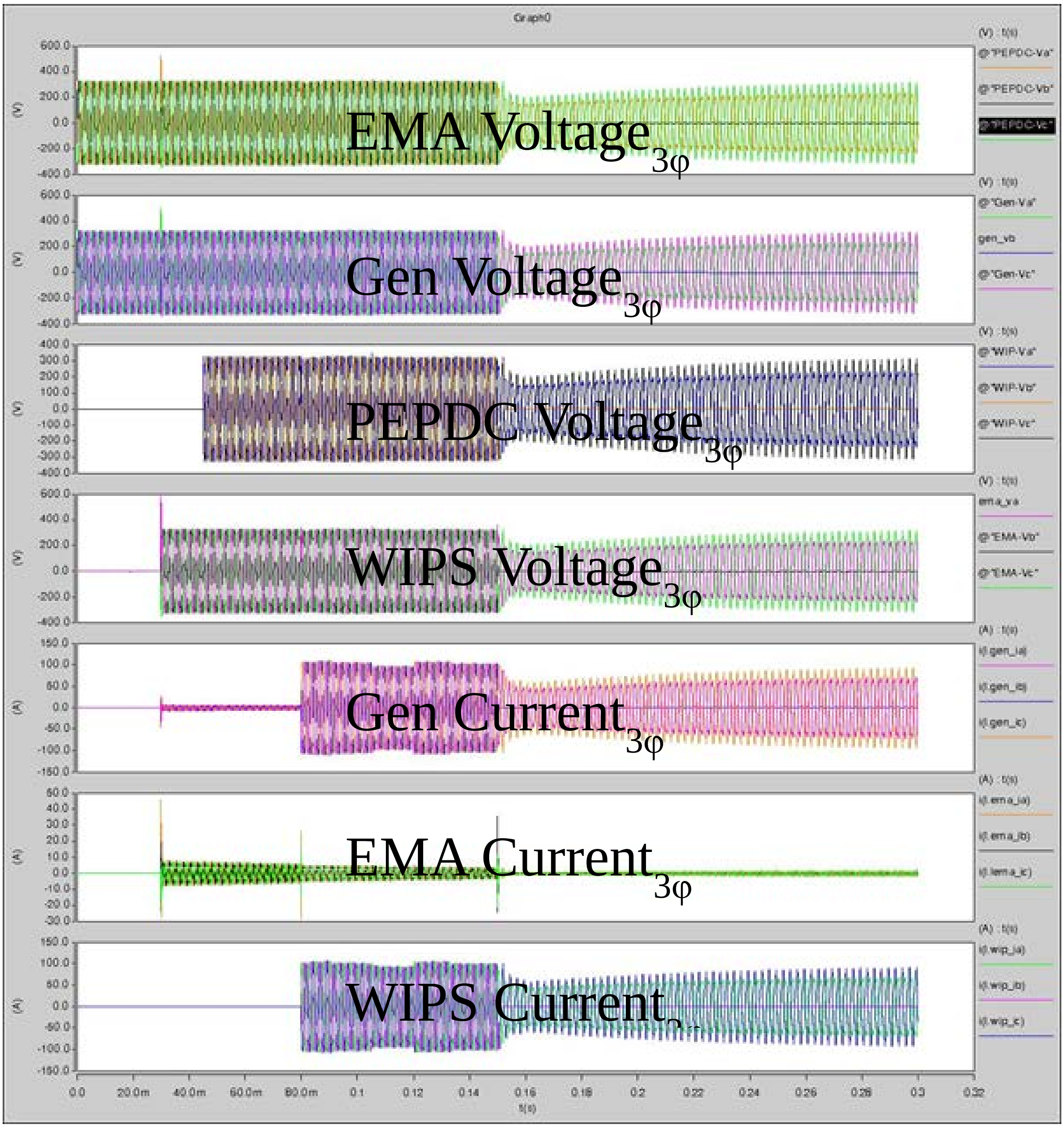

Fig.3b: Faulty Simulation Data

2.2 Technical aspects of the Fault Detection Tool

Developed using Artificial Neural Networks (ANN)
Architecture

- Three layers
- Back-propagation
- Various combinations of tangent sigmoid and logarithmic sigmoid functions

- Varying number of neurons in middle layer

Twenty different ANN topologies were examined in total to compensate for the partial degradation of the available simulation data sets

- The simulation data-sets were originally produced in Saber using a varying sampling rate. The re-sampling process resulted in unavoidable data degradation.

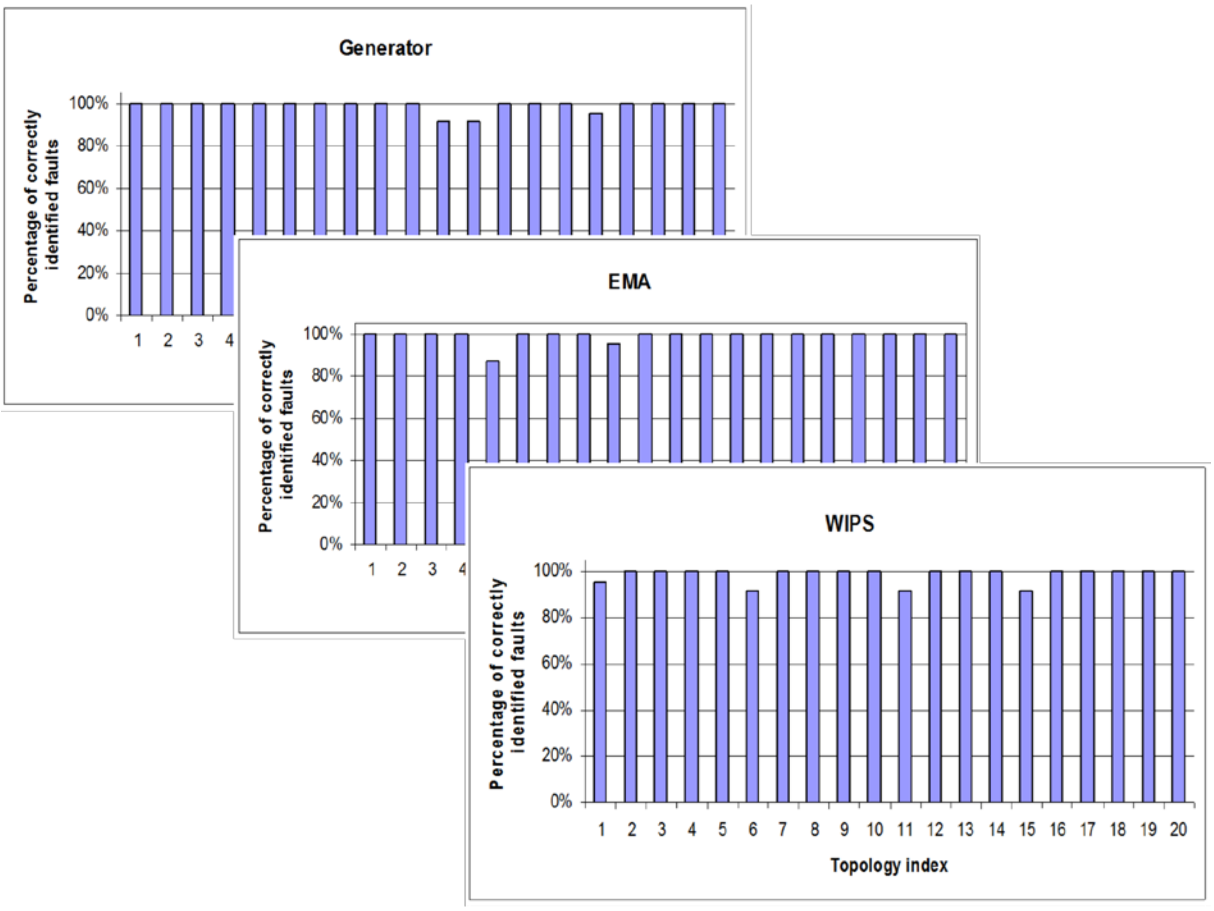

Fig.4: Fault detection results for the topologies examined

2.3 Technical Challenges

- Independent verification of fault-free simulation environment
- Reduces the number of physical tests necessary to validate the measurement data
- One common tool for simulation/certification processes and in-flight service conditions.

2.4 Main Business Benefits

- Online confirmation of validity of measurement data and
- Reduced number of physical tests

3. CONCLUSIONS

The developed Fault Detection tool, based on ANN, successfully detected faults in the combined electrical network. The Fault Detection tool was designed and implemented to work with online collaboration platforms and purpose-designed automated interfaces that enable manufacturers and third-party suppliers to collaborate online in a structured and direct manner, while preserving traceability and versioning throughout the design and simulation cycle. This Fault Detection tool verifies and validates global aircraft electrical networks for their conformance to proper fault simulation requirements towards certification from simulation.

ACKNOWLEDGMENTS

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