A Novel Tool for the Conceptual Design of Aircraft Electrical Power Systems

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EXTENDED ABSTRACT

A novel modelling and analysis tool is being developed for the evaluation of aircraft on-board electrical power systems with regard to their weight, power behaviour and reliability. The tool is intended for use in the conceptual design of such electrical systems. Diverse methodologies are integrated in the tool, to cover the mentioned analysis aspects at the same time. The recent trend towards more-electric system technologies on civil aircraft has motivated the creation of this tool.

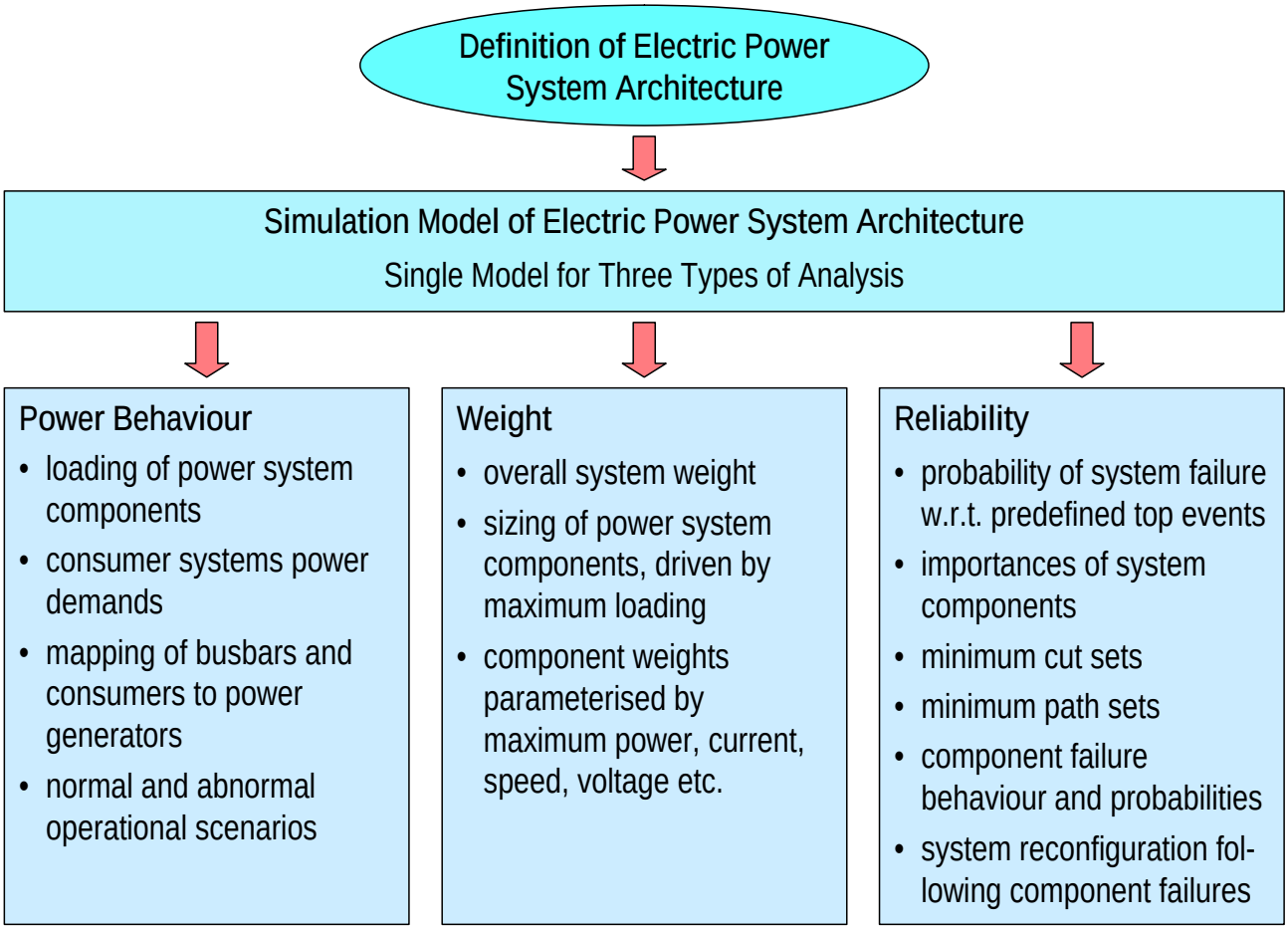
The tool comprises a dedicated model library containing object-oriented, physical models of electrical power system components. The model library is implemented in the Modelica language [1]. It is hierarchically structured to accommodate various models of different complexity, such as interfaces (plugs, databuses etc.), basic electrical components (wiring, contactors, busbars etc.), more integrated electrical components (generators, rectifiers, converters etc.), power users (motor drives, heatings etc.) and entire system architectures. Each component model also includes a physical representation of the component's failure behaviour and probability. Thus, the library provides an infrastructure for the creation or adaptation of simulation models of electrical system architectures.

The system architecture models also include the open / close logics of the various busbar contactors, which link (or disconnect) the power generators and users through the electrical network. Thus, the capability of aircraft electrical systems to be (re-)configured is built into the models. This allows to simulate the system architecture models for various normal and abnormal operational scenarios, e.g. for system operation in degraded mode subsequent to component failures or for power user design loads. Therefore, the maximum load / power / current to be carried by each component of the electrical system can be evaluated. This leads to a sizing of the components and to an estimation of their weights, as well as the overall system weight.

The graphical model editor of Modelica / Dymola [2] supports, by commonly known drag and drop, an easy creation of the system architecture models, which include numerous component models and dedicated network contactor logics. The object-oriented modelling approach helps in the creation of models that also have a concise appearance, similar to a schematic sketch of an electrical system.

The weight and power analysis procedures are implemented in the model library and are processed simultaneously with a system architecture model by the Dymola translation and simulation engine. The reliability analysis is performed by a Matlab script, which is developed specifically for the new tool described here. The procedure relies on the reconfiguration capability of the system architecture model. The probabilities of occurrence of defined top failure events [3], e.g. the loss of voltage on a busbar, are computed, as well as the importances of system components. The importance of a component is a measure for its structural and probabilistic influence on the probability of a top failure event. Cognition of the component importances helps to identify potential weak points or unnecessary redundancies in the electrical system architecture.

The following schematic depicts the kinds of analyses, needed inputs and results computed by the tool.



In conclusion, the tool is prepared to evaluate electrical system architectures w.r.t. their weight, power behaviour and reliability, and the mentioned kinds of analysis are performed by employing a single simulation model of the system. The advantages of having to create or adapt just a single system model are a lower change effort associated with modifications of the system architecture, and the analyses results can be managed more easily and consistently. This is a technological advancement compared to existing analysis methods for weight, power and reliability, which require different representations or models of the system dedicated to each kind of analysis.

The newly developed tool enables to rapidly evaluate different electrical system concepts and to find the trade-offs between them, which supports the optimisation [4] of system architectures. Therefore, the tool is suited to improve the design process of aircraft electrical power systems.

This research is being conducted in the frame of the European MOET (More-Open Electrical Technologies) Project [5].

REFERENCES

[1] Modelica Language. http://www.modelica.org

[2] Dynasim Dymola. http://www.dynasim.se

[3] Lloyd E. and Tye W. (1982). *Systematic Safety – Safety Assessment of Aircraft Systems.* Civil Aviation Authority (CAA), London, ISBN 0 86039 141 8.

[4] Schallert C., Pfeiffer A. and Bals J. (2006). *Generator Power Optimisation for a More-Electric Aircraft by Use of a Virtual Iron Bird.* 25th International Congress of the Aeronautical Sciences (ICAS), Hamburg.

[5] MOET Project. http://www.eurtd.com/moet/