

Approach for an Integrated Multi-Domain Aircraft Energy Model

David Lazarovich and Sang-Joon Lee

Honeywell, Electric Power Systems CoE

Copyright © 2008 SAE International

ABSTRACT

In recent years, More-Electric and All-Electric Architectures are being adopted extensively for next generation of aircraft. In this new architecture, many systems rely primarily on the use of electrical energy. Hence, there is a significant increase in the demand of electrical energy that is managed by the electric power system of the aircraft. A significant increase in demand of electrical power is also observed during recent years of aircraft development.

In the More-Electric Architecture, aircraft systems are heavily dependent on electric energy. This fact results in higher extraction of mechanical power from the engine via power take off shafts as opposed to energy extraction via bleed air. The balance of extracted energies has shifted from pneumatic extraction to mechanical extraction and conversion into electrical power. The transition to the use of increased levels of electrical power leads to increased complexity and criticality of the electrical system of the aircraft. Having the use of electrical energy as common denominator, aircraft systems are becoming increasingly correlated. Consequently, the impact of change in the power usage or quality in one system affects the availability or the quality of power for other systems. Therefore, recognizing these interactions between aircraft systems becomes of significant importance for the safe and efficient operation of the aircraft.

This paper presents an approach for an integrated multi-domain energy model used for simulation and analysis of power flow to different systems at the aircraft level. The model captures the behavioral and functional aspects of different systems with focus on the energy handling and translation to electrical energy under various flight conditions. Superimposing of the power quantities used by the different utilization systems models provides the means to understand the impact of energy parameter change in one system on other connected systems and on the overall availability of power at the aircraft level.

In the preliminary stages of modeling, the overall electrical energy model is based on combining subsystems energy model data with power usage data extracted from aircraft load analysis for systems not yet modeled. The combination of the two data stream gives the overall energy picture. The models may be used to analyze the energy transfer at both behavioral and functional level. The selected subsystems for which energy models were created have either a significant power draw or are continuously varying as function of flight conditions or pilot intervention, such as Environmental Control Systems and Hydraulic systems. In addition, a generic aircraft load analysis for a More Electric Aircraft that includes information about the loads and their interdependency with other system is also used to predict power utilization upon different flight phases and flight conditions. Once additional detail models become available, they may be integrated in the general energy model of the aircraft, while the relevant load analysis data extracted from the value maybe eliminated.

The overall model was used for analysis of electrical power transients and transfers during varying aircraft conditions such as impact of an aircraft maneuver, altitude gain during 'climb' and generators failures on the overall power availability.

An extension of this model was used for conceptual design of power management dynamics at the aircraft level. An approach of power management study is also briefly discussed in this paper.

INTRODUCTION

With More-Electric and All-Electric Architectures being adopted extensively for next generation of Aircraft, there is a significant increase in the energy managed in its electric form in the aircraft. In the new architectures, most of the systems rely primarily on the use of electrical energy; best examples are the Environmental Control systems (ECS) which transitioned from the use of

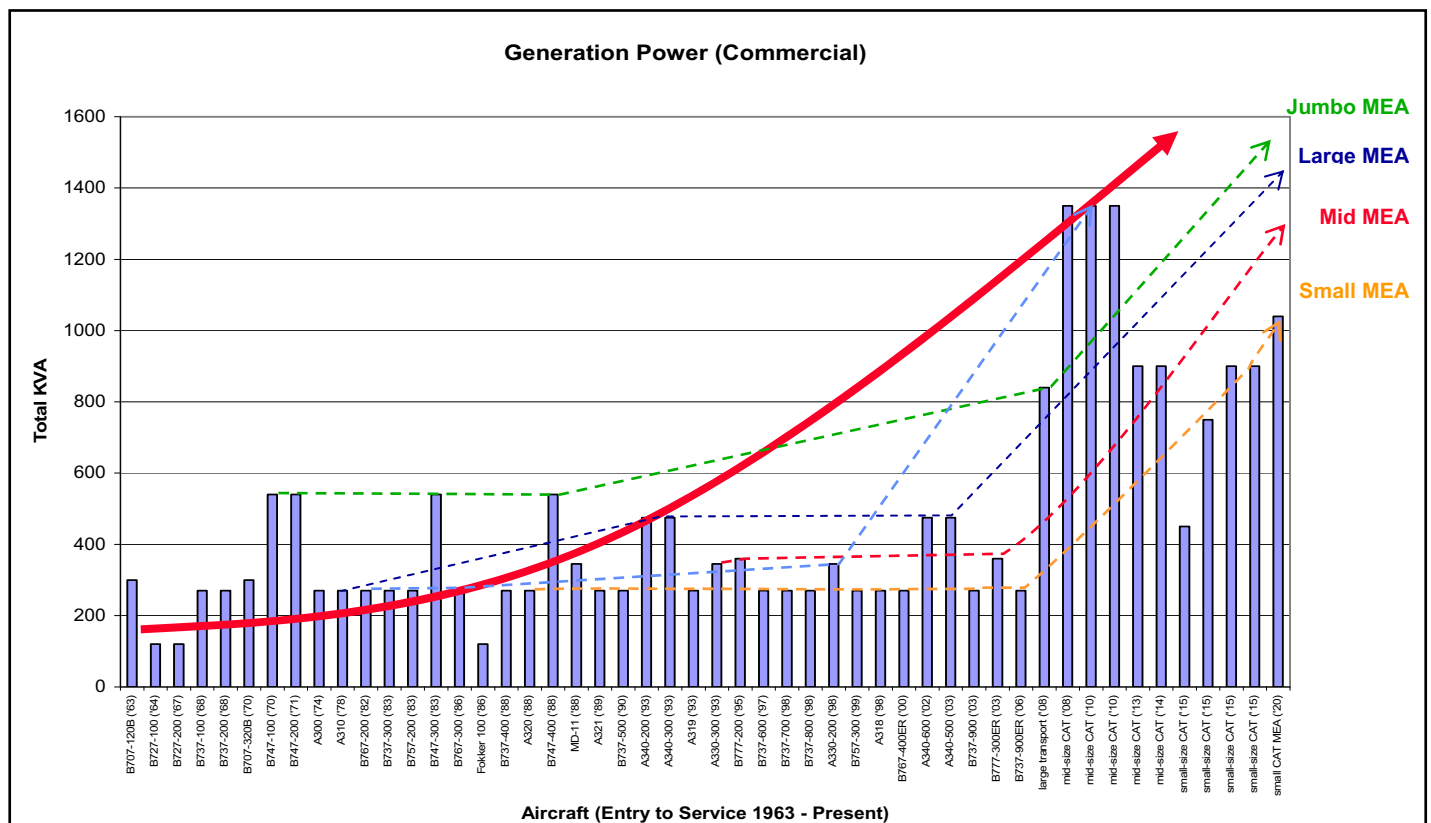


Figure 1 – Utilization of Electrical Power in Aircraft along Time

pneumatic energy (bleed air) to electrical energy or De-icing systems that rely on the use of more electrical energy. Figure 1 represents graphically the increase in the utilization of the energy in electrical form in aerospace along time; a significant increase is observed during the more recent years.

Dependency on electric energy by aircraft systems has resulted in higher extraction of mechanical energy from the engines via power take off shafts; the balance of extracted energies has shifted from mostly pneumatic extraction to mechanical extraction for conversion into electrical energy. The transition to the use of increased levels of electrical power leads to increased complexity and criticality of the electrical system of the aircraft. The use of electrical energy having become a common denominator, the utilization systems interact and become interdependent.

The impact of power surges in one system affects the availability or the quality of power for other systems; therefore recognizing these interactions becomes of importance for the safe operation of the aircraft.

Regarding the quality of power, designers have also to address the issue of application of overloads or shock loads due to the multitude of constant power loads on MEA aircraft. Application of an overload may cause an allowable dip in the bus voltage – this will trigger an increase of the load current of the constant power load which in turn may lead to an additional decrease in the bus voltage; this may become a chain reaction and from

here to the under voltage trip of a generator or other power source is just a short way.

The paper presents an approach for an integrated multi-domain energy management model used for simulation and analysis of power flow to different systems at the aircraft level.

Superimposing of the power quantities used by the different models provides the means to understand the impact of a power change in one system on other connected systems and on the availability of power at the aircraft level.

Analysis paths to be shown in the paper via the use of models:

- Impact of an aircraft maneuver (i.e., landing gear stow using hydraulic power) on the power extraction at the aircraft level.
- Impact of altitude gain during 'climb' on the power extraction (i.e., increased air flow to be provided by the cabin air compressors).
- Impact of a generator failure on the overall power availability and redirection of power transfers at the aircraft level.

An extension of this model is being used for the conceptual design and development of algorithms of power management dynamics on an aircraft.

Creation of the multitude of models and their integration into a single model representing the subsystems of an airplane is a daunting task. Therefore,