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A simulation of aircraft fuel management system

Juan F. Jimenez, Jose M. Giron-Sierra *, C. Insaurralde, M. Seminario

Departmento ACYA, Fac. Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain

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Abstract

Aircrafts usually have several fuel tanks, and there are fuel transfers among these tanks along a flight. These transfers are controlled with valves, and may follow several alternative paths, since structural fuel system redundancies are provided for evident reasons. An on board program for the management and reconfiguration of the fuel system must be developed and tested. The article introduces an aircraft fuel management system simulation, which provides a platform for the study of the fuel system logic and sequencing that the on board program must implement for normal flights and for malfunction cases. The simulation environment can be easily modified and extended, for instance to consider the use of new components. A specific example is considered: an aircraft with six tanks in the wings and a tail tank. The article presents a two-layer model, the use of the model for simulation experiments, and some illustrative examples.

Keywords: Aircraft fuel systems; Control reconfiguration; Hybrid system simulation

1. Introduction

Depending on the number and location of tanks, the fuel in an aircraft is subject to certain transfers for several purposes. In general, the aircraft fuel system [5,6] has structural redundancies, so there are alternatives to get around possible problems, such as malfunction in a valve or a pump, and get the transfers done. A fuel management system, with a specific computer, is responsible for the monitoring and control of the fuel system under normal or abnormal conditions. It is convenient to provide a platform to study the logic that the computer must implement to respond to a variety of circumstances. The platform must be flexible and intuitive enough, in view of the many types of aircraft fuel systems and the characteristics of the normal and abnormal cases to be specified and studied.

This article introduces a MATLAB-Simulink environment for aircraft fuel management studies. This simulation environment has been developed as part of a European Research Project, denoted "SmartFuel", which proposes a new aircraft fuel management system using smart components [2,3,8]. The purpose of the simulation is to test the use of new components in an airplane fuel system. Simulink was selected as a suitable tool to

* Corresponding author. Tel.: +34913944387; fax: +34913944687.
E-mail address: gironsi@dacya.ucm.es (J.M. Giron-Sierra).

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develop the model by two reasons: first, its inherent interactivity, second it deals well with hybrid systems. A particular fuel system configuration for a two-engine aircraft has been specified, as an initial reference for system logic study. The two-engine aircraft is relatively large and is intended for long flights. Its fuel system includes seven tanks. One of the missions of the fuel management system is to control the position of the aircraft centre of gravity (CoG) along the flight.

It is interesting to notice the different benefits of establishing a simulation in a research involving several partners. Part of the partners in the SmartFuel Project are aircraft sensors and actuators manufacturers, others are final users (big aircraft companies), and some others are university research groups. The process of making the fuel system simulation served as a common table to establish communication between different mentalities, and is effective as part of a requirement engineering step. Once an operational version of the simulation is established, this becomes a very useful tool for decision support and system logic analysis, development and testing.

The order of the article is as follows: first a description of the process to be simulated is made; then there are two sections devoted to the development, and then the use, of the simulation; this is followed by a section with examples, showing system reconfiguration features; finally the article draws some conclusions.

2. The process to be simulated

Some aircrafts, especially those intended to perform large intercontinental flights, can be furnished with a fuel tank (trim tank) in the tail. This tank helps to get a good aircraft trim angle along the flight and to maintain aircraft stability, shifting backwards the aircraft CoG by means of the extra fuel located in such tank. Fig. 1 shows a schematic of the aircraft fuel system that has been specified for this research. There are three fuel tanks in each wing, and one trim tank in the tail. Each tank is furnished with suitable sensors to gauge the fuel quantity contained in it. There are two engines, LE and RE.

The fuel transfers between tanks are controlled with valves and pumps. Certain fuel transfers can be done with no necessity of pumps, for instance, by taking advantage of wings inclination for simple gravity transfers. The pumps ensure certain functions, for instance, engine supply (pumps P1–P4).

Notice that the system embodies some fuel path redundancies, to guarantee engine supply even when there are component failures. For instance, gravity transfers between the tanks of the left wing can be done through

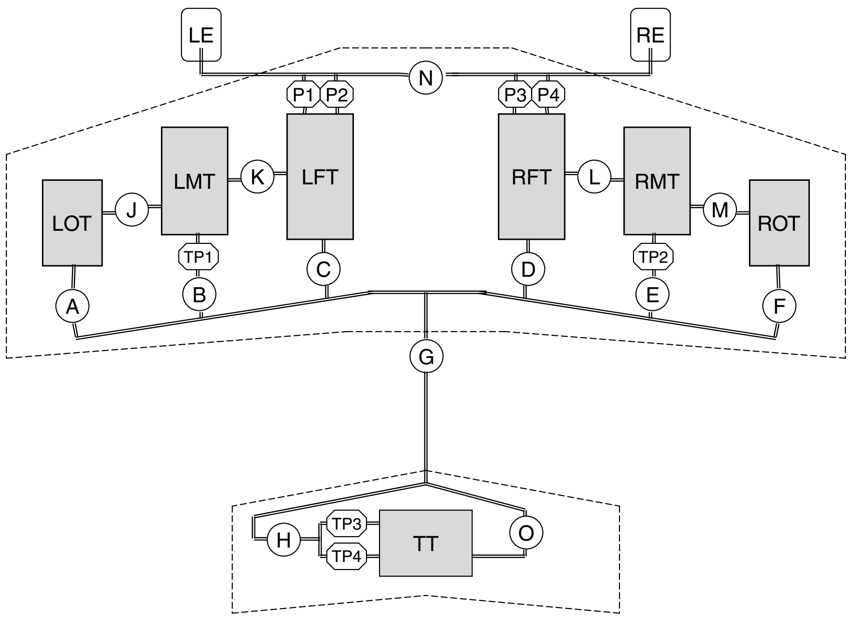

Fig. 1. Schematic of the aircraft fuel system.