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# Scheduling of an aeronautical final assembly line: a case study

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**Abstract**

Within the aeronautical industry, there has been in the recent years a high effort towards digitalization. This has resulted in a deep transformation of the way of working all through the product lifecycle. This digitization has included the use of scheduling and line balancing support tools, which have been extremely important in the case of the industrialization of new products and existing products re-industrialization. In this case study we present the re-industrialization of a final assembly line from the line balancing point of view. It completes other previous studies that presented the theoretical framework for aeronautical final assembly line balancing.


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*Keywords:* Case Study; Aeronautical Industry; Line Balancing

## 1. Introduction

Smart factories are one of the main characteristics of industry 4.0. This implies a further integration and digitalization of all the business processes, including manufacturing. As a result, digitalization is becoming one of the main topics in every industry [1].

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In [2] Mas et al studied the influence of PLM (Product Lifecycle Management) tools in the two main aircraft manufacturers. They stated that the use of PLM tools had been a strong enabler for shortening development and industrialization periods. In the same way, the use of different digital solutions at the shop floor has provided an increase of competitiveness, improving the processes performance. Some examples are the use of virtual Reality or Laser projection [3], [4]. Within all these tools, scheduling and line balancing have been left aside for long. Nevertheless, they are of great importance in the production context.

To the best of our knowledge, there are little examples on real use cases of line balancing and scheduling within the aeronautical industry. In 1994, Scott [5] presented a work on the main issues that need to be included when modelling an aeronautic assembly line, such as human resource availability, space constraints and precedencies between jobs. A more recent study, published by Heike [6] different alternatives for aeronautical assembly lines with regards to the use of constant or variable cycle times on flow shops. Ziarnetzky [7] use simulation for a similar study.

On top of this, in [8] Menéndez et al presented a first approach to a methodology for the first industrialization of a final assembly line in terms of line balancing and task scheduling. It addressed the balancing line activities to be completed during a program development phase. As a result, a method was established in order to help the industrialization engineers evaluate the impact of the design decisions (including product design, but also processes, jigs and tools) on the assembly line performance during the whole program lifecycle. In 2015, Borreguero [9] extended this approach to the production phase.

This methodology has been applied to a final assembly line during its re-industrialization in order to reach the program ramp up. Until the moment of the study, the organization had been focused on the delivery of the first prototypes. Facing the ramp up meant that a constant delivery rate must be assured, together with on quality and on cost manufacturing.

The aim of this case study is to provide an overview of the main methodology and outcomes of this re-industrialization.

The remainder of this paper is structured as follows: Section 2 provides a more detailed description of the case study context. Section 3 is dedicated to the different steps of the re-industrialization. Finally, Section 4 is dedicated to the conclusions.

## 2. Case study context

This case study has been developed in the final assembly line of Multi Role Transport Tanker Aircraft (MRTT). It is a military aircraft used for in-flight refueling as well as military transport.

It is built using a finished Airbus A330 civil aircraft as a basis. The modifications to be done on the aircraft for its transformation include most of the technologies present in other final assembly lines. In all, MRTT production is a complex process that involves 2000 work orders, more than 9000 tasks and more than twelve months' lead time at the moment of the study.

Before the re-industrialization, production was made using the hangars in parallel. Each serial number was converted in one hangar from its arrival until the delivery to the client with the same dedicated team. Due to the production rate, there were at most three aircrafts being produced in parallel. This had been a strong asset during prototype development, as the team working on a prototype followed its development from the product definition to the final aircraft delivery.

However, as the industrialization was consolidated, some drawbacks of this organization where identified. To begin with, the three parallel lines had a negative impact in knowledge sharing between different serial numbers. Also, due to the long lead time (several months), there was a small impact of training curves, as the same team rarely repeated the same work and, if they did, it had been long since their previous execution. Also, there was a need to improve intermediate quality gates so as to have a clear vision of the aircraft status and work in progress.

This is why, in the beginning of the ramp up, it was decided to turn the production flow into a pulse line. The benefits of pulse lines have been widely discussed. For Boeing [10] it is one of their nine tactics for Lean Manufacturing implementation. They reported that the implementation of a moving line resulted on a reduction of the total process lead time in a 16% for the 717 and a 50% for the 777 [11].

Some of the advantages for this re-industrialization were: