Journal of Air Transport Management 17 (2011) 68–73

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

An AHP analysis of air traffic management with target windows

Lorenzo Castelli [a], Paola Pellegrini [b,*]

[a] DEEI, University of Trieste, Via A. Valerio 10, 31427 Trieste, Italy
[b] Department of Applied Mathematics, University Ca' Foscari, Dorsoduro 3825/E, 30123 Venice, Italy

Keywords:
Air traffic management
Analytic hierarchy process
SESAR

A B S T R A C T

The main operational concept of Single European Sky ATM Research Programme is the notion of business trajectory. One possible implementation is based on the notion of a contract of objectives; an agreement among the main air traffic management actors on spatial and temporal intervals called target windows. These 4D windows are defined prior to flight departure by the airlines, airports and air navigation service providers to increase punctuality. We use an analytic hierarchy process to assess the opportunity of implementing this concept by considering the views of experts. The findings indicate that there are net benefits for airlines and air navigation service providers but not for airports

1. Introduction

The Single European Sky ATM Research Programme (SESAR) aims at modernizing air traffic management (ATM) infrastructure by identifying the technological steps and priorities for implementing a new target concept (SESAR Consortium, 2007a). This concept is centered around the notion of business trajectories that consider airspace users' intention with respect to any given flight. The ATM services are organized to guarantee that this trajectory is carried out safely and cost efficiently within infrastructure and environmental constraints. Business trajectories are expressed in four dimensions (latitude, longitude, flight-level and time) and evolve out of a collaborative decision making (CDM) process developed in two phases: flight planning and execution. The former starts several months before the day of operation: the flight is defined according to the airline schedule and specific resources are assigned to it (aircraft type, crew, network resources, etc.). On the day of the operation, the flight is made as closely as possible to the plan and deviations are managed to minimize their impact on the larger schedule.

One mechanism to formalize the business trajectory is through contracts of objectives (CoO), as developed by the Contract-based Air Transportation System (CATS) research project (www.cats-fp6.aero). The CoO is a formal commitment among airlines, airports and air navigation service providers (ANSP) for the completion of each flight. It consists of a sequence of spatial and temporal constraints that constitute milestones to be met during a flight's execution. These 4D intervals are the target windows (TW). They are defined at each area where responsibility between actors is transferred (e.g., between different area control centers). The determination of the TW in each CoO is by negotiations that take into account constraints such as runway capacities and en route congestion. Any divergence in the flight from the planned CoO, for example due to unforeseen weather conditions, triggers a re-negotiation.

Under the current system, flight plans filed by airspace users constitute an intention to fly and there is no formal commitment to adhere to these. Moreover the various actors interacting during the execution of a flight are not fully aware of their differing objectives and priorities, and this can lead to a sub-optimal management of operations (Eurocontrol Experimental Centre, 2005). The CoO provides a formal description of each ATM actor's objectives and requirements, as well as a mutual commitment to respect them, thus leading to improvements in planning and earlier detection of unplanned disruptions.

This paper looks at the opportunity for implementing the CoO/TW concept, and weighs the benefits and drawbacks with respect to the current system. The assessment is made with the support of a group of experts from the CATS consortium. Subject matter experts belong to air traffic stakeholders: Air France Consulting (airline view), ENAV, the Italian Air Navigation Service Provider (ANSP view), and Flughafen Zürich AG, the company managing the Zurich airport (airport view). They are fully aware of the details of the CoO/TW concept having all been involved in the CATS project from the beginning. The assessment uses an analytic hierarchy

* Corresponding author.
E-mail address: paolap@unive.it (P. Pellegrini).

0969-6997/$ – see front matter
doi:10.1016/j.jairtraman.2010.05.006

process (AHP) methodology, which allows incorporation of qualitative and quantitative considerations (Saaty, 1977, 2000).

2. The AHP methodology

The goal of the analysis is to compare the benefits and drawbacks linked to the implementation of the business trajectory through the "CoO/TW concept of operations" (CoO/TW) *vs.* the "Business-as-Usual" (BaU) scenario. In accordance with the AHP methodology, we decompose this decision problem into a hierarchy of criteria (or elements) which are likely to have an impact on it.

We consider six independent hierarchies: flight-planning and execution phases for each of the three actors. Each hierarchy allows the actor to choose the alternative that maximizes its utility, defined as the difference between benefits and drawbacks associated with implementation. The net utilities are not expressed in monetary terms because some elements of the hierarchies are hard to evaluate in monetary terms.

The different hierarchies are depicted in Figs. 1–3. Lower nodes represent the criteria and the arrows show the relationships among them. Evaluation of the criteria is by pair-wise comparisons between all elements at the same level of the hierarchy (i.e., sharing the same parent node). After the validation of the hierarchies, experts assess the comparisons: for each pair of criteria, they identify the one more important and decide on the magnitude of the difference relying on a Saaty's (2000) scale where the relative importance of two nodes may be equal, or moderately, strongly, very strongly, and extremely different. These judgments are translated into a numerical scale, and a local priority number in the interval [0,1] is associated with each criterion. Then we derive a global priority value for each criterion by multiplying its local priority with the global priority of its parent node. Following the same rationale, the experts compared the two alternatives (CoO/TW and BaU) with respect to each node at the lowest level of the hierarchy, and a priority value was computed in the range [0,1] with the sum over the alternatives adding to one. As we are comparing just two scenarios, the alternative whose priority value is higher than 0.5 is the preferred option. Using the global priorities and the alternative priorities of the nodes at the lowest level, we calculate an alternative priority value for each node up to the root node. The best alternative for each criterion, and eventually for the actor's final decision, is thus found.

In Figs. 1–3 the global priority values are seen in parentheses next to each node. The best alternative for each criterion is also highlighted: the solid line is thick when CoO/TW is the preferred option, dashed when BaU wins, and thinner when the alternatives are equivalent (Castelli and Pellegrini, 2010).

3. The airline perspective

In the flight-planning phase an airline utilizes human resources and equipment to prepare its operations, with the main tasks of the staff being split into training and performing their main activities, which requires time and may produce stress (Fig. 1(a)). On the benefit side, the implementation of the business trajectory may foster a common responsibility in the management of the whole system. In fact, the clear definition of actors' specific duties for each flight may allow, in case of a disruption, to quickly identify the causes of the problem, and who must act to solve it. Furthermore, the agreement and compliance with everyone else's requirements may enhance the traffic predictability. This may lead to an increase of the quality of service, a reduction of the scheduling buffers that airlines introduce to account for the possible delays, and an increase (or better use) of the capacity. In turn, a scheduling buffer reduction may allow decrease of aircraft maintenance costs, crew costs, airport charges, and aircraft ownership costs (i.e., depreciation, rentals and leases of flight equipment) as a better exploitation of the fleet is possible through, e.g., an optimized aircraft rotation (Cook et al., 2004).

An airline executes the business trajectory relying largely on human resources because operating costs of equipment are, in the execution phase, of marginal importance (Fig. 1(b)). Similarly to the planning phase the main benefit drivers are the common responsibility and the increase of predictability. Greater predictability may

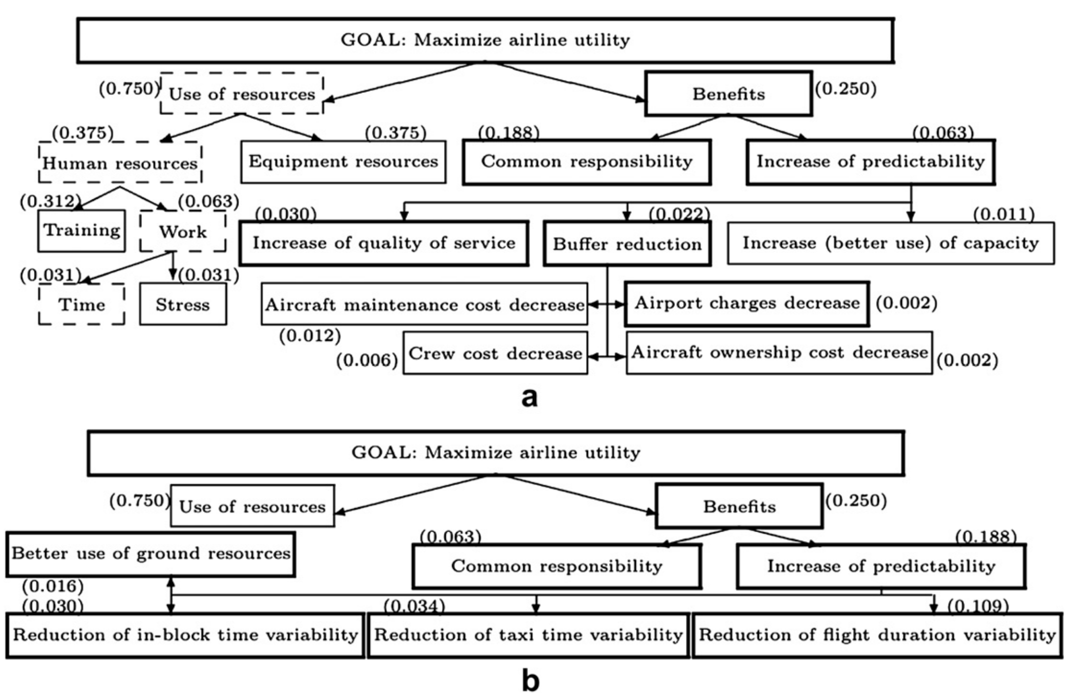

Fig. 1. AHP model: airline perspective (a) planning phase and (b) execution phase.