Chapter 4
Cooperative Control for Ground Traffic at Airports

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ABSTRACT
With the sustained increase in air transportation, resulting in increased operational costs, potential danger with conflictive traffic conditions and delays for passengers and airlines, ground traffic has become a critical issue for many airports. In this communication the ground traffic at an airport is considered to be composed of three dependent flows: aircraft, passenger vehicles and servicing vehicles. It is assumed in this study that each type of vehicles belongs to a common pool which attends every arriving or departing aircraft. The objective here is to propose a global control structure based on cooperation between the different agents responsible for the management of each fleet to reduce overall aircraft traffic delays at airside.

INTRODUCTION
With the sustained development of air transportation over the last decades, airport capacity has remained a permanent issue for airport planners and operators. Until recently, airport capacity was considered only through its two traditional bottlenecks: the runways system and the passenger’s terminals. However, today, aircraft ground traffic at airports has become also a critical question with important influences on security and efficiency and new ground traffic management and control systems with a higher degree of automation have been introduced.

In this communication, a framework for modeling airside traffic at airport is proposed. This framework is useful since there exists many different ground operations organizations, often related with the geometry of each particular airport, and it is not possible to elaborate a common mathematical model of ground operations applicable to all airports. Then considering an airport where the airside includes near and remote parking positions for aircraft and two types of ground vehicles, a set of operational constraints guaranteeing feasibility is
introduced. Then the formulation of an optimization problem for the management of airside traffic is considered. It appears that a global approach for the optimization of ground traffic management is too complex to be tackled in real time. Then a new approach based on multi agent systems is developed to provide a feasible solution to this problem. Simulation results are displayed and discussed.

AIRSIDE OPERATIONS AT AIRPORTS

Airside operations at airports are closely controlled and monitored by several systems, which are mainly operated by air navigation systems which make available detailed information about the progress and status of airside operations to each involved airport traffic decision maker. When incoming or departing flights are delayed, the airport decision makers are informed, and can thus adapt their operations, in order to integrate this delay. However, when considering airport ground traffic, until recently, there was in general no information available for ground operators in the airport, about the status and progress of aircraft ground traffic and of ground operations. Some airlines have already developed, for their own use, information systems which are able to provide information about ground operations on the apron. Also, some systems have been developed, mainly in the case of freighters, for the monitoring and control of the different fleets of vehicles on the airport. But these systems, designed in general to attend the specific needs of each fleet manager, are not able to share information with other ground vehicle management systems and the other airport ground operators. This lack of coordination between the activities of the different airport ground actors (airport operations, ATC, airlines, luggage delivery system, catering systems, passengers boarding and disembarking resources, etc.) generates frequently unnecessary delays for aircraft and an inefficient use of the available fleets of ground service vehicles. This leads in the mean term to a diminution of the overall airside capacity of airports, since its ground component has been recognized recently (see figure 1 where $\Phi^a$ is the flow of arriving aircraft, $\Phi^d$ is the flow of departing aircraft and $N^0$ is the number of grounded aircraft) to have a relevant impact on it.

It also generates a large difficulty to anticipate delays and operations disruptions and to re-organize accordingly the different ground operations.

Different projects have been already realized to overcome these difficulties, providing in real time not only a global view of instant ground traffic at airports but also providing some degree of anticipation to compensate for predicted delays. Today these new information systems allow the development of improved ground traffic management systems. The resulting management structure should be composed of three levels:

- a planning level where ground vehicle fleets and workforce are dimensioned, fleet depots are localized and traffic ways are established;
- an operational level where resources (vehicles and staffs) are assigned on the short term to the different ground operations;
- a control level where vehicles are localized and controlled on line.