Modelling and Simulation of APOC Operations

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Abstract—**This work aims at developing an agent-based platform that allows to model and analyze decisions made by different stakeholders in an Airport Operations Centre. We will develop a methodology combining agent-based modelling and field/lab behavioral experiments for identifying the incentives behind the decisions of the stakeholders in an Airport Operations Centre environment. Once, the causal relationships have been identified, these will be translated into an agent-based environment so, it will be possible to have a virtual environment for identifying which incentives are the best for aligning the objectives of the center, considering the diversity of objectives present in the system. The causal-relationships identified in the study will be validated with a human-in-the-loop environment already developed under the SESAR program. This study is an interdisciplinary one which integrates simulation, decision making and behavioral science in the airport operations center environment**.

Keywords-ATM; simulation; airport operation, economical behavior

I. Introduction

Today in many airports, operational decisions are often made with a limited knowledge of the most pertinent data. In addition, decisions by a given actor are often taken in isolation without reference to other actors who may be impacted by such decisions.

The Total Airport Management concept (TAM) is developed under SESAR2020 PJ04 and instantiated under the Airport Operations Center (APOC) at airports [11]. APOC enables a wide range of information to be centralized and visualized by the various actors interacting with airport operations, in order to put in place, the best commonly agreed airport operations plan (AOP) and better mitigate performance deterioration situations.

The purpose of this project is to study the APOC environment including innovative techniques like behavioral analysis and agent-based modelling (ABM), to further improve collaborative decision-making.

Airport collaborative decision-making (A-CDM) is seen as a means to address disruptions by better sharing information locally between stakeholders such as airport operators, ground handlers and air traffic control. Needless to say then that if disruption hits an airport then it can have a significant knock-on effect on the rest of the network [24]. APOC stakeholders have to make important decision at disruptions but they have internal conflicts because the stakeholders have different objectives to pursue.

This will be performed along two parallel processes. The first level will be to analyze the obvious relationships between the APOC actors, and the second level will be focused on the identification of the hidden human-related relationship between the APOC actors.

II. Background

To accommodate capacity and have a smooth operation, it is necessary to change the management paradigm; for that reason, the Airport Operations Centre (APOC) [10,11,21] has raised as an answer to the new necessities of coordination. However, managing an airport involves using many resources and different actors participate altogether (airport operations, airlines, Air Navigation Service Providers) and they often operate in an environment where there is not a harmonized approach to collaborative airport planning. The APOC concept is a means by which the efficiency of overall airport operations may be addressed. However, as it has been already identified, collaboration is a must and it is required to make the concept work properly.

Furthermore, a common observation in experimental studies, of public goods mainly, is that, in environments with a finite horizon, cooperation levels are initially rather high but then decrease steadily over time [8]. During this study one of the objectives will be also to model the behavior in cooperation environments, such as the APOC. What it will be studied once the behavior is modelled, is the type of instruments or incentives that should be implemented in order to revive or foster cooperation in an APOC or to establish a certain level of cooperation amongst the involved actors which has been demonstrated has positive outcomes. Similar studies have been performed, the most relevant is the one performed in an AOC (Airport Operational Control Center) where the authors obtained good results that proved the benefits of ABS (Agent-Based Simulation); however, they followed a rule-based implementation. In order to overcome this limitation [13], it will be necessary to develop what we called 2nd generation simulation agents that are not only able to sense, think and act accordingly to their environment and externalities, but also apply decision-making internal models that are validated by field or laboratory experiments thus enabling the development of a virtual environment that simulates with high accuracy the environment and decision-making process in the APOC. The motivation for studying these issues comes from the analysis of organizations made in behavioral economics and the need to find ways to combat organizational decadence and in particular in the APOC environment which is considered a crucial organizational change for improving efficiency in ATM (Air Traffic Management) [21].

The approach merge different areas of science, on the one hand, in the agent-based research field it will be a breakthrough if by combining these methodologies we are able to overcome the current limitations of agents that behave based on empirical rules extracted from inference or correlations. On the other hand, by combining these techniques, we will positively impact ATM management within the APOC, thus identifying the causal relationships that motivate the different actors to collaborate less or more towards a common goal: efficiency in the system operation. The different techniques to be developed in this study are the development of Agent-based technology, knowledge from the realm of behavioral and experimental economics and aviation. With the combination of these techniques, it will be possible to better align or find a balance amongst the different objectives present in the APOC like punctuality indicators, passenger service, turnaround times, throughput among others; with the final objective of improving the coordination and efficiency of the operation of an airport.

The main hypothesis in this study is that by developing a socio-technical approach which combines methods from the behavioral economics field with simulation techniques like agent-based modelling it will be possible to develop intelligent agents which put together in a particular environment like the APOC could contribute to identifying the main blockers for cooperation between actors. Furthermore, with the development of the independent agents, it will be possible to evaluate what actions can be implemented for increasing cooperation amongst them and it will be possible to find a balance for the different objectives pursued by the different actors that participate in the APOC. The identified solutions can be evaluated using a human-in-the-loop environment which will confirm the validation of the intelligent agents.

In this work, the specific aims are the following:

- Development intelligent agents that simulate the different stakeholders present in an APOC environment (airlines, Airport ops and ANSPs).
- Develop a methodology that integrates the causal behavior of actors in the agent-based environment.
- Simulate the operations performed in an APOC making use of the developed agents.
- Analyze the behavior of agents using the virtual environment and propose policies or methods for enhancing cooperation amongst the stakeholders.
- Validate the developed approach in a virtual environment.

A. APOC Roles

The different roles of the APOC are divided into three sections (Fig. 1): Starting point Airside, Terminal and Landside [11].

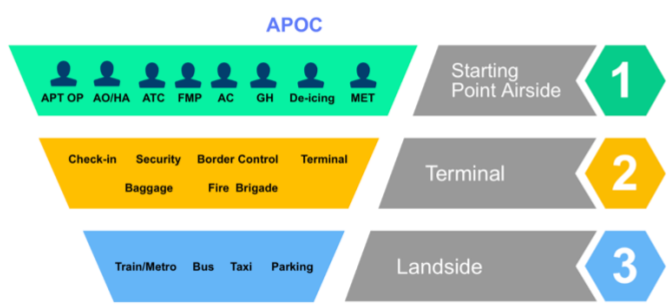

Figure 1 APOC Roles

The airside area includes all parts of the airport where aircraft are operated or serviced, runways, taxiways, apron, aircraft parking stands, de-icing facilities and dedicated maintenance areas.

Landside is practically all that is not airside. The landside is an area where passenger transit from and to the airside is conducted.

In this context, landside includes but is not limited to the terminal buildings (check-in, security, border control, passenger gates, etc.) as well as access facilities to the airport (e.g. car parking areas, trains, access roads, etc.).

The most important roles for the airport operations are the ones of the Starting Point Airside that involves:

- APT OP: Airport Operator
- AO/HA: Aircraft Operator / Handling Agent
- ATC: Air Traffic Control Unit
- FMP: Flow Management Position
- AC: Airport Coordinator
- GH: Ground Handler
- De-icing
- MET: Meteorological Specialist

In the APOC we also can find all the airport's key players involved in managing passengers, aircraft and baggage processes [25]. There are a lot of different companies working there like baggage handling companies, security companies, air traffic control provider, technical services, among others, in total there is an approximate of 140 people working at the APOC. Based on the information collected, they collectively take the necessary decisions. In this way, smooth and proactive communication with the companies and services concerned is guaranteed.

In general, airport processes have benefited from improved coordination and the airport can more readily anticipate different scenarios. At the same time, APOC enables different partners to respond more agilely when faced with changes in daily operations, as information is rapidly available to all and centralised decisions can be made quickly around the table with all stakeholders involved.

Finally, APOC has a distinct added value in crisis situations. When a crisis inside the airport emerges – or outside but with impact on the airport – all stakeholders assess the situation together on the spot. A coordinated action and communication plan are rolled out, with the specific goals to keep operations running and to help passengers.

The APOC has been implemented in different airports like London Heathrow, Paris Charles de Gaulle, Brussels International Airport and recently at Amsterdam Schiphol.

III. Methodology

We will use a methodological approach that combines simulation, agent-based modelling and behavioral economics experiments for developing what we called 2nd generation simulation agents that are not only able to sense, think and act accordingly to their environment and externalities, but also apply decision-making internal models that are validated by field or laboratory experiments.

First, we have inputs that the APOC receives; it could be information about daily operations. All the different stakeholders within the APOC receive this information so they have to make decisions based on it. We will model this information and the relationships within the APOC to identify policies using a combination of ABM and experimental economic techniques. The behavior identified in the experiments will be modeled using machine and deep learning models [22,23] to improve the intelligence of the agents.

The main hypothesis is that with the combination of these techniques, it will be possible to better align or find a balance amongst the different objectives present in the APOC like punctuality indicators, passenger service, turnaround times, throughput among others; with the final objective of improving the coordination and efficiency of the operation of an airport.

The methodology follows different phases (Fig. 2) in a horizon of three years. The structural approach will enable us to construct progressively the different elements and functionalities required for modelling the APOC on the one hand, and for parameterizing the agents on the other. The different steps to follow are:

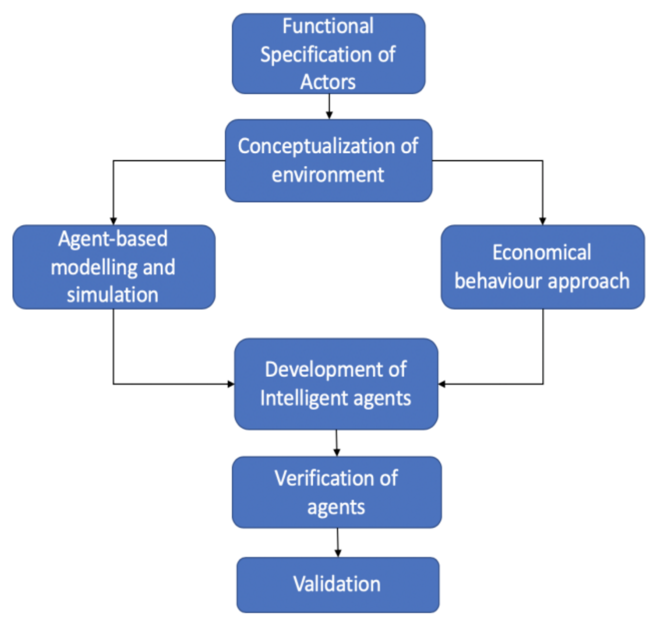

Figure 2 Methodology phases

- Functional Specification of Actors: In this state, we will make a parameterization of the different actors that participate in the APOC, what is required to specify are the inputs, decision, functions and bargaining power for making the final decision for a specific situation.

- Conceptualization of environment: this phase consists of the conceptual interaction of the different actors and how they will cooperate with each other and their environment. This phase depends on the conceptual definition of an APOC in reality.
- Agent-based Modeling and Simulation: An environment will be codified where the actors can get external input and stimulus (disruptions) and based on their own objectives will try to make the best decision; during the decision process they will need to negotiate with the other actors to get to a final decision.
- Economical behavior approach: This phase will consider the different architecture and design of experiments to be performed with a human-in-the-loop environment to identify potential collaborative policies.
- Development of Intelligent agents: Once we have the results from the experiments and with the simulation model we can implement the new parameters to have the correct behavior of the agents, and also we will implement machine and deep learning techniques such as reinforcement learning to improve the intelligence and the decision making process of the agents.
- Verification of Agents: Once developed and codified, the initial logic will be verified by making different controlled experiments for the individual agents. This will allow to identify if the logic they follow is in accordance with reality.
- Validation: For this task, it will be necessary to perform a cross validation where some results from lab/field experiments are used for comparison of the results of the virtual environment.

IV. CONTRIBUTION

This proposal is innovative because we would develop a new methodology to approach socio-technical environments combining cutting-edge knowledge from ABM, experimental/behavioral economics and machine learning techniques. All these applied in the modelling of the APOC will ultimately enable us to determine new policies for stirring the control center toward a more efficient operation. The methodology will be easily applied in a different environment than aviation-related such as ports, cargo systems, urban transport, among others.

V. CONCLUSION

We have introduced the initial concept of the use of ABM with Behavioral Economics for developing a methodology that enable us the design of policies and the identification of incentives for increasing collaboration in the APOC environment. The methodology presented is a combination of techniques that have been proved to be efficient in their own knowledge areas; i.e. ABM for simulating individual agents and behavior of independent people/actors, behavioral and experimental economics for identifying how people make decisions in an economic environment and simulation itself as the overarching technique that enable putting together all the knowledge in a virtual environment.

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