Ionut-Cristian PEREDERIC, Ionel SIMION

VIRTUALIZATION OF AIRPORT OPERATIONS
Framework for a virtual environment

Abstract: *Any undertaking starts from a need, regardless of what that need represents for the one taking the first step on a new, or different path. By bridging existing and emerging technologies we can set throughout adequate monitoring and precise control a current that would allow any type of system to have a better flow of information or materials.*

Keywords: *state of affairs, automation, case study, airport, overseer, product design, framework*

1. INTRODUCTION

Air transportation is expected to double its intensity in the next 20 years, in Europe for example, or even become ten times as dense in other parts of the world, take China, or Asia in general for the matter of fact. And, regarding facts, the equipment used to manage the flow of the airplanes around the world has changed over the last decades.

In the view of the European Commission, current air traffic control systems are close to becoming obsolete and are ill-suited for the rapid, economic and reliable development of aviation in Europe, particularly as expectations have changed:

- Passengers want efficient, affordable and safe transport;
- Respect for the environment is becoming a major constraint;
- 11 September 2001 showed that airplanes can be a threat to the safety of the population.

In aviation, knowing exactly what is happening is of upmost importance. For example, the "trend" in aviation is to lower fuel consumption, either by optimizing flight paths, timing, or sequencing the aircrafts (4D trajectory in short), or burning "plants" along with the current fuel in order to save the environment and all, oh, and lowering costs, or better to say lower incidents and accidents.

In conclusion, as stated on SKYbrary, regarding the SESAR projects, that's already in its final phase "If no proactive steps are taken to better manage increasing traffic density, the cost of air transport and the various risks associated with it will rise."

2. PRINCIPLES APPLIED

2.1 System theory

System theory is the interdisciplinary study of systems in general, with the goal of elucidating principles that can be applied to all types of systems at all nesting levels in all fields of research. The term does not yet have a well-established, precise meaning, thus I can freely extrapolate and interpolate on it, but systems theory can reasonably be considered a specialization of systematic thinking, a generalization of systems science, a systematic and strategic approach.

Self-regulating systems are found in nature, including the physiological systems of our body, in local and global ecosystems, and in climate and in human learning processes.

Systems theory serves as a bridge for interdisciplinary dialogue between autonomous areas of study as well as within the area of systems science itself.

Fig. 1 Basic System Theory.

In figure 1 we can see the basic system theory used in the project. I want to tackle the complexity of an "organism" such as an airport and reduce it to simple sets of input and output variables. From there on, the task is only to figure out how to achieve these desired outcomes, the favorable outcome, while studying, copying and mutating the available technology into something not only new, but adaptable as a stand-alone product.

2.2 System engineering

System engineering is an interdisciplinary field of engineering that focuses on how to design and manage complex engineering projects over their life cycles.

Issues such as reliability, logistics, and coordination of different teams (requirements management), evaluation measurements, and other disciplines become more difficult when dealing with large or complex projects, thus systems engineering deals with work-processes, optimization methods, and risk management tools in such projects.

Systems engineering signifies only an approach and, more recently, a discipline in engineering. The aim of education in systems engineering is to simply formalize the approach and in doing so, identify new methods and research opportunities similar to the way it occurs in other fields of engineering.

The International Space Station is an example of a largely complex system requiring Systems Engineering.

Most commonly, many feasible solutions can be found, and a sufficient set of constraints and cost function must be defined to produce an optimal solution. This situation is at times advantageous because one can present an opportunity to improve the design towards one or many ends, such as cost or schedule.

2.3 Keep it simple

"Everything should be made as simple as possible, but not simpler" – *Albert Einstein*

The KISS principle states that most systems work best if they are kept simple rather than made complicated; therefore simplicity should be a key goal in design and unnecessary complexity should be avoided.

The phrase has been associated with aircraft engineer Kelly Johnson (1910–1990). The term "KISS principle" was in popular use by 1970. Variations on the phrase include "keep it short and simple" and "keep it simple and straightforward".

There isn't anything much to add about this principle, it's more like a philosophy of designing something, rather than a theory, that if we were to use the strategic thinking from system engineering.

2.4 Product Design

Product design is essentially the efficient and effective generation and development of ideas through a process that leads to new products [1].

In a systematic approach, product designers conceptualize and evaluate ideas, turning them into tangible inventions and products. The product designer's role is to combine art, science, and technology to create new products that other people can use. Their evolving role has been facilitated by digital tools that now allow designers to communicate, visualize, analyze and actually produce tangible ideas in a way that would have taken greater manpower in the past.

Other aspects of product design include engineering design, particularly when matters of functionality or utility (e.g. problem-solving) are at issue, though such boundaries are not always clear [2].

3. SPECIFIC OBJECTIVES

There are one or more major subjects I would like to discuss in my paper; If we were to think about the framework as a whole, it is just one subject; if we were to see the machinations of this framework we can divide it into a few major components:

- A Passenger Flow Management System, or Automated Passenger Flow Management System, in short APFM System (hawking's, wasted energy, harnessing, control)
- Automated Runways (color codes, access, overview, oversight)
- Overseer System (step one)
- Virtualization (step two)

The steps above are an approximate split of the future framework, which will turn any sector, or system to be more specific, into a clear, safe and efficient organism (using the word organism here because if we were to take into account the case of an airport, by implementing a real time monitoring, communication and control system, we would be basically turning the airport into a machinery similar to a living entity).

3.1 Case Study 1: Automated Passenger Flow Management

Airlines schedule and sell tickets to passengers for a transportation service in point A to point B pairs, or, as known as in aviation, between Origin and Destination (O/D). The building block of airline transportation is a flight between an origin and destination airport.

A flight is defined by a unique date, flight number, an origin/destination, a scheduled departure time, a scheduled arrival time, an actual departure time, and an actual arrival a time.

A flight is also defined uniquely by the available seats, load factor, and by its performance status: on-time, delayed, cancelled, diverted.

Feasible sequences of flights to ferry passengers from an origin to a destination are known as passenger itineraries. A passenger itinerary is defined uniquely by a single flight (e.g. AAL 123) or by a sequence of flights (e.g. UAL 345 and UAL 456), along with the number of passengers on the itinerary.

A passenger itinerary supported by a single flight is classified as a direct itinerary. A passenger itinerary supported by more than one flight is classified as a connecting itinerary. Each passenger itinerary is also uniquely classified by an itinerary status: on-time, delayed, rebooked due to missed connection, rebooked due to cancellation, and diverted.

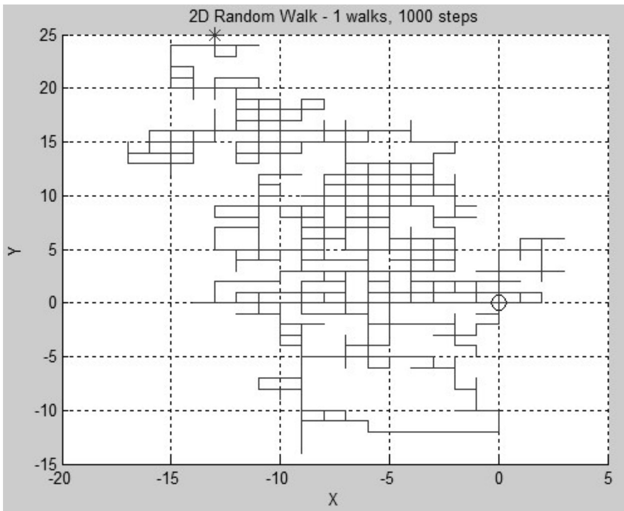

Fig. 2 2D Random Walk generated by Matlab code.

Basically a system of flow management is one of the most promising approaches in avoiding the current congestions aviation is experiencing. To design such a system, one must address to the flow management problem (FMP), which by itself is challenging even on a basic level (when based on a "macroscopic" model. Flow management represents a stochastic and dynamic problem and requires a discretized representation of flows; additionally, complications are caused by the need to consider the distributive effects of flow management strategies as well as taking into account capacity/demand, flow conservation and relationships associated with elements of the airport in general.

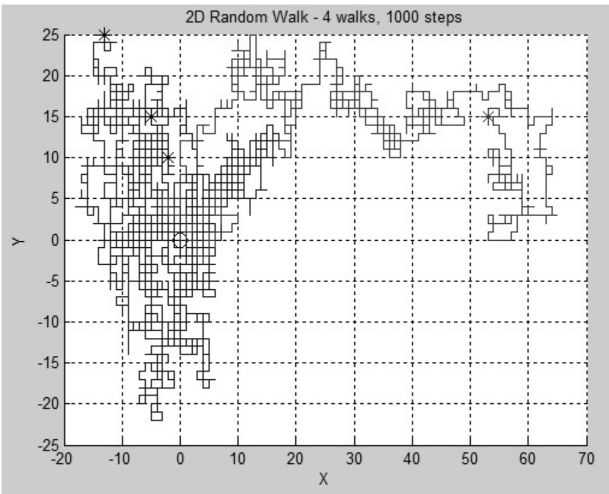

Fig. 3 2D escalated Random Walk generated by Matlab code.

In figure 2 and figure 3 we can see randomly generated paths for a person that takes walks of 1000 steps in this case, I have selected this number based on the maximum number of steps one takes while wandering about, searching for something, until losing patience and asking for directions. The purpose of these representations is to show the amount of wasted time and energy which could be harnessed in a constructive way, let us say, by using a hydraulic system that basically transforms our steps, our walk, into power (kinetic energy into electricity). Thanks to the ingenuity of the human race, this technology already exists.

A real study conducted with a prototype system in place, which will monitor the flow of people over the length of one random month will suffice to get better data and attempt to make formulas and exact estimations of the whole length traveled, efficiency, energy provided and overall impact of the system.

3.2. Case Study 2: Automated Runway

The Runway Status Lights concept was first discussed in 2002 and once it had been validated, the task of development and overseeing the initial operational trials of its various elements was then passed to the MIT Lincoln Laboratory sponsored by the FAA under a USAF Contract [3].

In order to present the idea of an automated runway, I will be using as a model Runway 18 / 36 from O'Hare International Airport (the version of the airport in use will be from 2004, since then, the airport went through several changes and automations.)

By using Microsoft Flight Simulator 2004 as the database; it was used Airport Design Editor 1.6 in order to import the data for our airport as seen in the figure 4.

By importing the data, we can proceed by selecting the required runway, in this case Runway 18/36 as it was denominated at that time by the Flight Simulator.

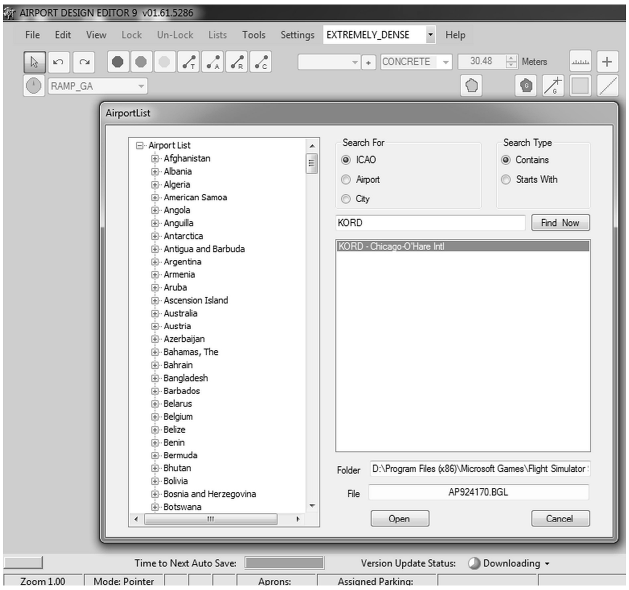

Fig. 4 Importing data from Microsoft Flight Simulator 2004 into Airport Design Editor.

Fig. 5 Targeted Runway as viewed from East to West.

Selecting the RWY we will get the following runway data:

Table 1

Runway Data

Runway	18 / 36
Heading	179.99
Width	45.72 Meters
Length	1628.55 Meters
Surface	Asphalt
Latitude	41.99
Longitude	-87.90
Alt	203.606 Meters

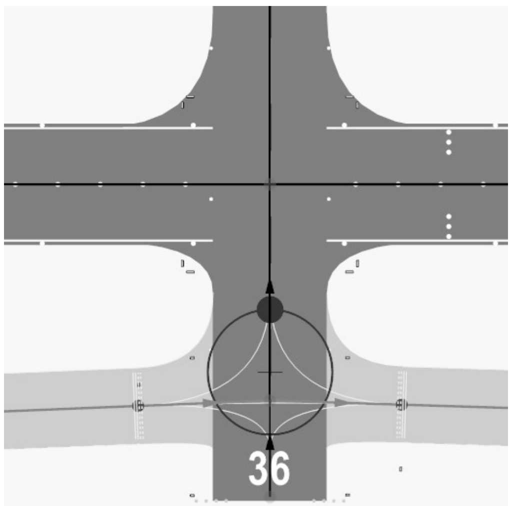

Fig. 6 First and second intersection point.

After this stage we can proceed to select the areas of interest. These are the intersections with other runways and taxiways.

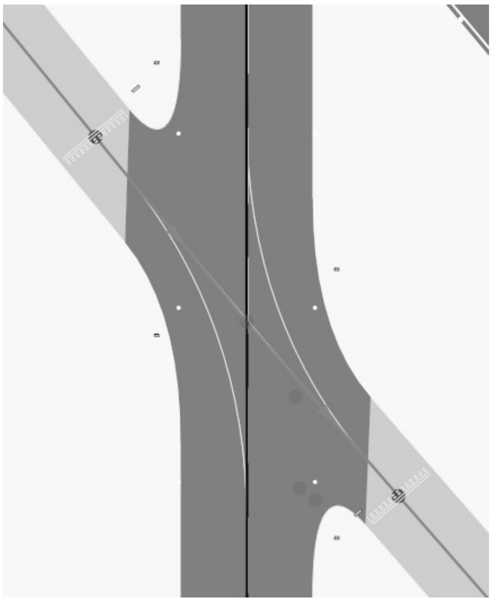

Fig. 7 Third intersection point.

For these we have the following color code explaining the lights:

Table 2

Explanation of the colour codes used on the intersection points

Red	Hold Short Taxi Point
Blue	Normal Taxi Point
Yellow	ILS Hold Short Taxi Point

By using the above and integrating them into an automated warning system [6], this will allow us to further reduce any issues that might appear on the runway, especially at airports with a high flow.

4. THE NEXT STEP, VIRTUALIZATION

Virtualization of a system is an idea that connects these three systems. It works by collecting all the information provided by the Overseer System and displaying it in a 3D environment.

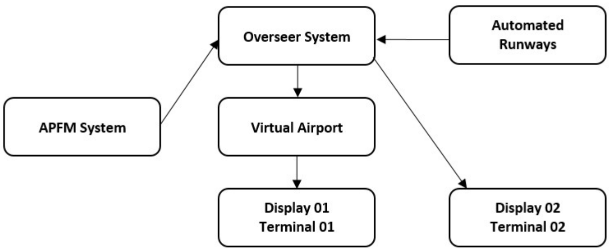

Fig. 8 Virtual Airport without the control option.

We shall call this environment the Virtual Airport, which is basically an accurate representation of all the machinations in an airport, all that is happening on an airport is shown in real time; from the passenger flow, to the movement of aircraft on the apron and runway.

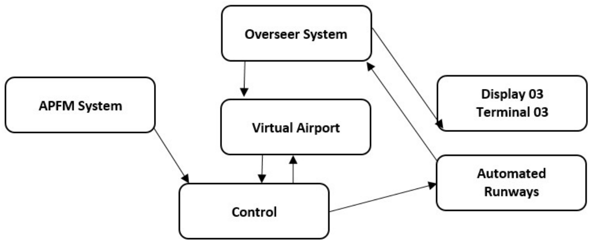

Fig. 9 Virtual Airport based upon the control option.

We was discussing the possibility to increase the overall safety and security as much as possible and to make runway accidents a thing of the past; this might not be far away if we were to add to the virtual environment the possibility to control everything in real time, of course with certain restrictions in place (the control will basically be limited).

5. CONCLUSION

This work represents a future framework, a collection of compiled information, thoughts and ideas that changed into the presented form.

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Authors:

Assist. PhD. student Eng. Ionut-Cristian PEREDERIC, University POLITEHNICA of Bucharest, Faculty of Aerospace Engineering, Department of Engineering Graphics and Industrial Design, E-mail: cristiperederic@gmail.com, Phone: 0040730735510

Prof. PhD. Eng. Ionel SIMION, Director of Department, University POLITEHNICA from Bucharest, Department of Engineering Graphics and Industrial Design, E-mail: ionel.simion@upb.ro, Phone: 0040748781561.