AUTOMATIC REAL-TIME AIR TRAFFIC CONTROL SYSTEM AND METHOD FOR MAXIMIZING LANDINGS / TAKEOFFS CAPACITY OF THE AIRPORT AND MINIMIZING AIRCRAFTS LANDING TIMES

NEED FOR THE SYSTEM

The continuous expansion of the air transportation business has put a huge strain on the aviation system with airport maximal capacity is becoming a limiting factor in meeting the rising demand for more flights. Due to the increasing number of flights, air traffic control in busy airports is one of the main challenges affecting the airport capacity.

According to the On-Time Arrival Performance National report, approximately 25% of all flights in the United States were delayed in 2014, while half of those delays were categorized mainly as volume-delays. The resulting delays have a significant economic impact, as the Federal Aviation Administration (FAA) estimates that flight delays cost airlines $22 billion yearly in the US.

In 2015, the direct cost of aircraft block time for U.S. passenger airlines was $65.43 per minute. Increased fuel consumption, aside economic effect, also has an important environmental effect.

Delayed aircraft are estimated to have cost the airlines several billion dollars in additional expense.

Studies estimate that flight and air traffic inefficiencies consistently cause aircraft to use 10% more fuel than necessary.

Airports will also be benefited by the increased punctuality of the operative schedules, while passengers will also benefit due to decrease in flight delays.

Since the runway delays (landing / takeoff) is often a bottleneck in an airport system, there is a great interest in optimizing usage of the landing and takeoff processes. By implementing the disclosed invention, airports will benefit from minimizing the runway delays and maximizing the runway capacity, thus the airport capacity is raised, workload on tower controllers is reduced, airlines' fuel consumption and operating costs are reduced, all without the need to construct additional runways.

PRODUCT OVERVIEW

The products relates to computerized Air Traffic Control (ATC) systems. The invention especially relates to the air traffic control optimization at landing / takeoff stage, while complying with a variety of regulatory and safety requirements.

Makor has developed a novel product for maximizing aircraft capacity through computerized air traffic control optimization at landing and take-off, wherein the air traffic control of the flight status of multiple aircraft is performed.

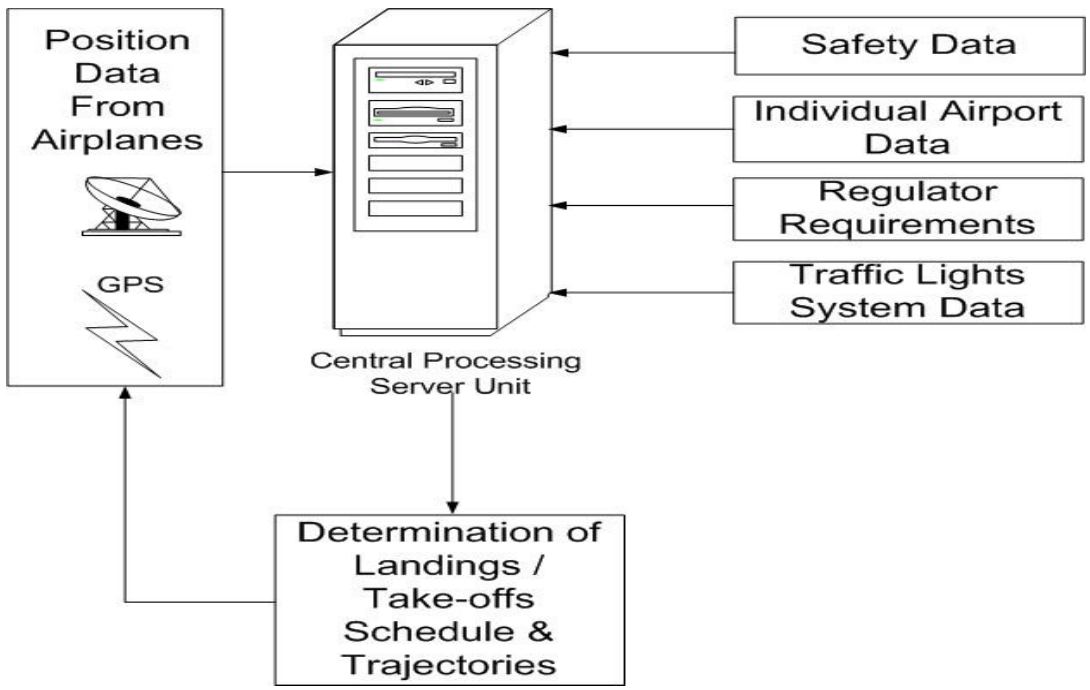
The main objectives of the model are the following:

1. Maximum aircraft landings / takeoffs for runway based on the real-time data;

2. Shortest/fastest landing 4D trajectory based on the real-time data.

Airport capacity is increasingly becoming a limiting factor in meeting the rising demand for more flights.

In such an environment, what is needed is a product for specification of an aircraft trajectory in terms of coordinates that allow use of higher capacity of traffic in a given volume of airspace while satisfying safety and regulatory conditions and compensating for deviations from a time schedule so that an aircraft is not required to fly with unrealistic velocity or unrealistic angle parameters, and with minimally optimal number of landings go-arounds.



Air traffic controllers in the airport tower monitor takeoffs, landings and ground traffic with visual and radar tools.

The ultimate goal of the novel product is to remove, or minimize reliance on air traffic controllers in maintenance of separation between aircraft on the landing / take-off stage.

The system can be either automatic, eliminating the need in the air traffic controllers, or decision-support system, facilitating more efficient work of humanmanaged air traffic control tower. System working parameters can be modified in a real-time mode, thus giving the air traffic controllers the flexibility to manage the system.

The system is designed in such a way that it can work, under safety standards and regulations, for all airports for a variety of runway' lengths, separation intervals and distances, final approach point lengths and heights, initial and final approach speeds, slopes, safety time intervals between landing and/or takeoff, takeoff duration, etc.

In contrast to the prior art systems, where static separations of fixed lateral and horizontal distances between objects are required, the present invention allows for dynamic real-time separation. As such, the aircraft multilateral air traffic control security separation is based on four main principles, as the system makes continuous determinations for each pairing of aircrafts within the system, and for all pairings of aircrafts as a whole:

1. On system set-up in the airport, the user will check and adjust airport specific landing parameters. If there is a collision probability, the user can adjust the parameters until no collision probability is expected. Such checks will also be performed on the real-time basis, performing preliminary checks considering a number of landings/takeoffs estimated per specific day.

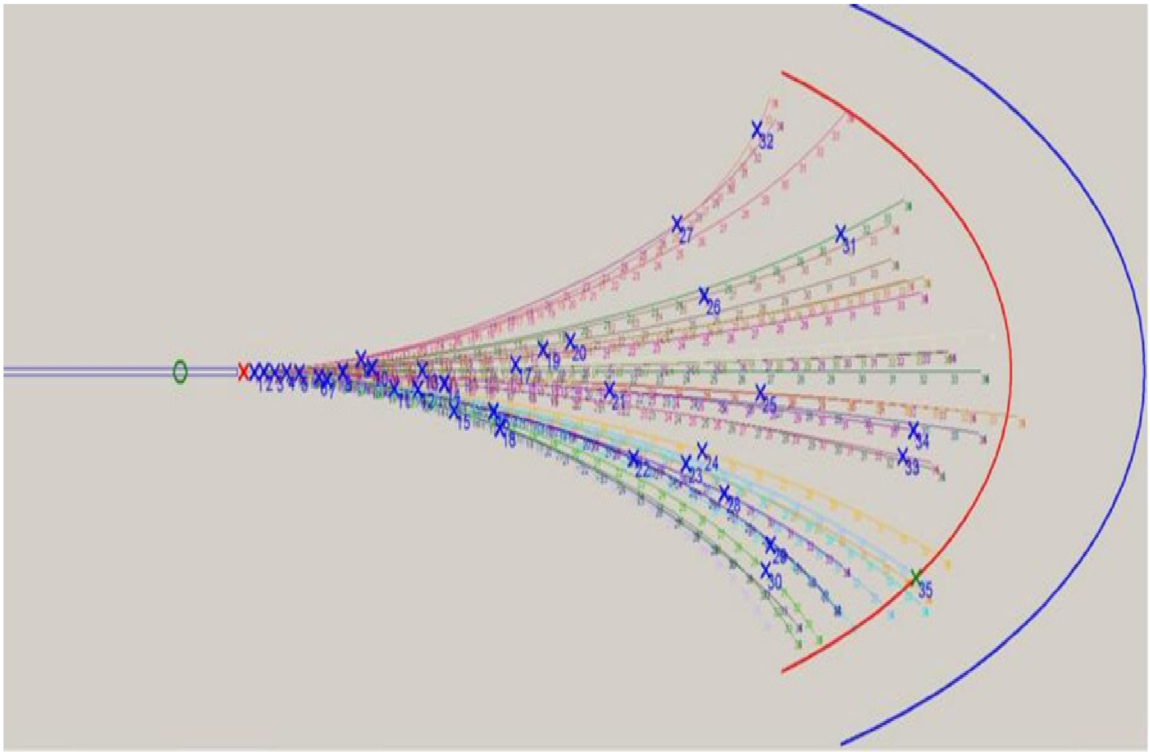
2. After the individual aircraft trajectory has been computed, the system checks if there is a safe passage throughout the proposed trajectory without collision danger. If there is a potential collision danger, then the trajectory will be modified, and the system will check if, and until, the new trajectory is collision-free.

3. Then, throughout the duration of landing, the system constantly checks if there is any new collision danger. If there is a new collision danger, the trajectory will be modified, and the system will check if, and until, the new trajectory is collision-free.

4. Additionally, landing traffic lights system will be further provided, such a system having changing colors depending on the availability status of the runway, wherein the color will be red, and when the aircraft will leave the runway area, the sensors will be activated and the light will be turned to the green.

The system computes possible 4D trajectories for individual aircraft based on the aircraft location and speed data, and based on the aircraft type and specific characteristics. For example, certain types of aircrafts require longer/bigger separation distances then the others.

The system generates and transmits to each and every aircraft a sequence of trajectory points based and tested by the system. The sequence is continuously updated. Between two consecutive sequences updates, the system checks the flight path till the end of landing.



Due to minimizing the runway delays and maximizing the runway throughput – an overall airport capacity is raised, workload on tower controllers is reduced, airlines' fuel consumption and operating costs are reduced and, therefore the pollution is reduced also.

The central processing unit computer gets the four dimensional positioning information (X, Y, Z, T (time)) on all aircrafts situated in the same landing/take-off area.

The aircrafts will be guided in the landing / take-off by providing them with the shortest landing trajectory under safety constrains for the optimized landing / take-off, fulfilling all necessary safety conditions.

The optimized landing in our invention is based on queuing landing / taking-off aircrafts by building a virtual arc-shaped line near the airport, and "catching" every aircraft at some certain point on this virtual arc near the airport, a plurality of points, we call those points: “identification arc”, and by building individually-located “starting points arc” built in such a way so to satisfy queue constrains.

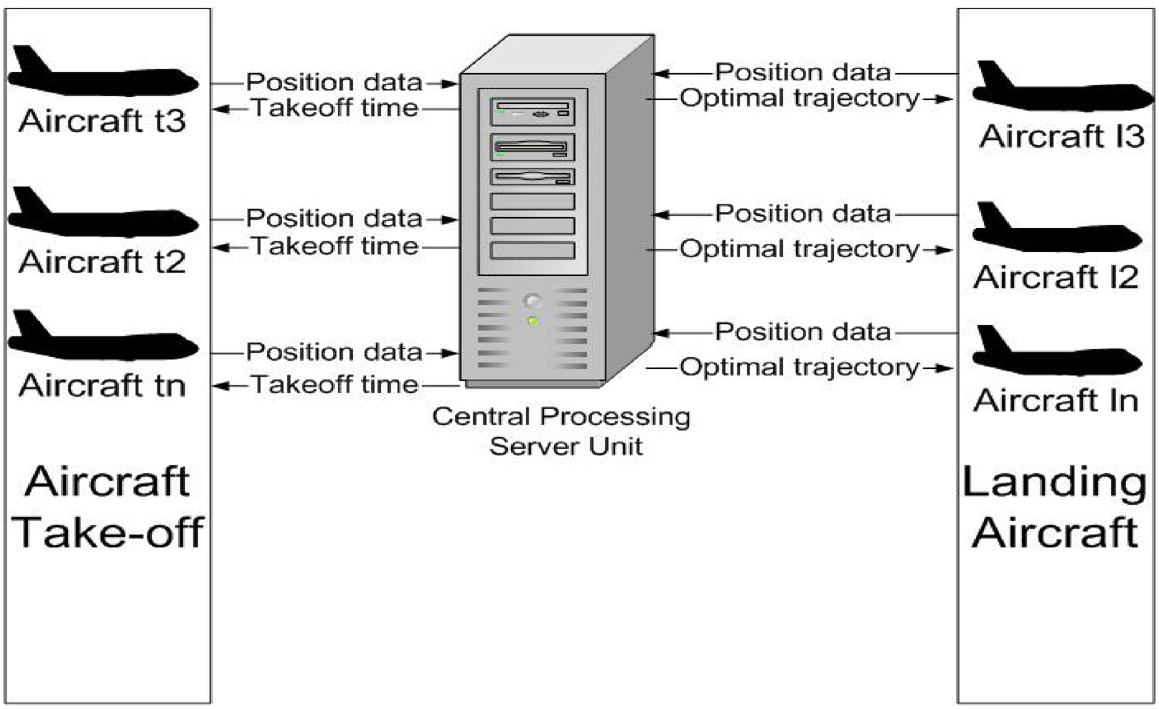
Takeoffs schedule queue is taking in consideration when scheduling landings while complying with security requirements. Takeoffs will be scheduled in such a way that they will leave immediately one after another taking in consideration security separation requirements. Landings and takeoffs can be performed on one or several runways.

The aircrafts will be separated by the number of parameters to ensure safety for the aircrafts according to the updated FAA / EASA standards. Accordingly, the model disclosed in the invention works under current FAA / EASA runway usage, precedence and time constrains.

The system uses ADS-B signals to provide pilots with accurate location and traffic information on surrounding aircrafts.

The primary technology used by our system to receive flight information is called automatic dependent surveillance-broadcast (ADS-B). ADS-B uses GPS signals to provide information to keep aircraft safely separated, and it provides air traffic controllers with real-time position information. Currently, almost 99% of aircrafts in Europe are covered with ADS-B receivers, and there is also a significant ADS-B coverage in USA and worldwide. ADS-B will become mandatory for most aircraft around the world by year 2020. ADS-B consists of two different services: "ADS-B Out" and "ADS-B In". “ADS-B Out" provides information about each aircraft, such as identification, current position, altitude, and velocity. The ADS-B transmits signal containing the aircraft location. ADS-B signal is picked up by a receiver connected to our system. Another technology which can be used by our system is the Wide Area Augmentation System (WAAS) that provides the ability to accurately determine coordinates of the airport to assist in automatic landing procedure, as it improves GPS signal accuracy from 100 meters to around 7 meters.

The signals from ADS-B will be an input for our system, and the autopilot instrument landing systems will receive an output consisting of an exact 4D trajectory, such an autopilot can operate independently, controlling heading and altitude, or it can be coupled to a navigation system and fly a programmed course or an approach with glide-slope. Modern autopilots use computer software to control the aircraft.



Landing aircrafts have priority over takeoffs, so aircraft waiting for the takeoff is waiting for the "green" signal. Such aircraft will be allowed to takeoff if time remaining to the next landing is larger than predetermined minimal time period and if the time past after previous takeoff is larger than the minimal waiting time for waiting for the takeoff.

Special landing traffic lights will be installed on the runway to increase the landing/takeoff safety; such traffic lights will have changing green/red colors.

NEED FOR THE SYSTEM

Since the runway delays (landing / takeoff) is often a bottleneck in an airport system, there is a great interest in optimizing usage of the landing and takeoff processes.

It is difficult for air traffic controllers to monitor the positions and headings of too many aircraft at one time on conventional equipment, and human controllers make unnecessary mistakes in separating aircraft. Using our system, due to eliminating the "go-arounds" and maximizing the runway throughput – an overall airport capacity will be raised and workload on tower controllers will be reduced.

Below is the summary of main advantages to all parties involved:

- **To the airports**:
  - Due to minimizing the runway delays and maximizing the runway throughput – airport capacity is raised, workload on tower controllers is reduced, airlines' fuel consumption and operating costs are reduced and, therefore the pollution is reduced also.
  - The system is especially beneficial to busy airports, increasing their throughput.
  - Less need to build new runways.

- By transitioning away from a manual, paper based system, controllers are able to concentrate more on the visual surveillance of the airport and aircraft, leading to increased situational awareness and enhanced safety.
- Airports will also be benefited by the increased punctuality of the operative schedules.
- Special approach traffic lights will be installed on the runway to increase the landing/takeoff safety.

• **To the airlines**: the invention is beneficial to the airlines since the reduction in operating costs. Fuel costs represent up to 30 percent of an airline's annual operating budget. Studies estimate that flight and air traffic inefficiencies cause aircraft to use roughly 10 percent more fuel than necessary. Small per-flight efficiency improvements can deliver significant fleet-wide savings over the course of a year. The system can be integrated with the NextGen program of FAA. FAA estimates airline benefits to be $51.4 billion with regard to implementing the NextGen.

• **To the passengers**: passengers will benefit due to decrease in flight delays. FAA estimates passenger value of time to be $79.7 billion with regard to implementing the NextGen.

• **To the environment**: increased fuel consumption, aside economic effect, also has an important environmental effects. FAA estimates passenger reduction in carbon dioxide emissions to be $400 million with regard to implementing the NextGen.

• **To the government:** Less need to build new airports and to add runways to existing airports.

- **UAV integration**: The same method can be used to integrate UAV/UAS to land in the existing airports without the need to build new airports and to add runways to existing airports, in accordance with appropriate FAA regulations in UAV/UAS domain.

Makor Issues and Rights Ltd.

17 Balfour St., Jerusalem 9210224, Israel,

tel: 972 2 6734913 fax: 972 2 6734859

email: makor@optimization.co.il

web site: www.optimization.co.il