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[Continued on next page]

(54) Title: SYSTEM AND METHODS FOR AUTOMATED AIRPORT
AIR TRAFFIC CONTROL SERVICES

(57) Abstract: A system and method for automating Air Traffic Control operations
at or near an airport, as a complete standalone automated system replacing the need
for a human controller to make aircraft movement decisions nor the need commu-
nicate with pilots, or as semi-automated, where a controller controls how the sys-
tem operates. The system with related methods and computer hardware and com-
puter software package, automatically manages manned aircraft, remote controlled
UAV and airborne-able vehicles traffic at or near an airport, eliminates ATC-in-
duced and reduce pilot-induced runway incursions and excursions, processes con-
trol messages related to aircraft or Pilots, communicates with Pilot over ATC radio
frequency, receives aircraft positions, communicates control messages with the air-
craft avionics, provides pilots a dynamic airport map with continuous display of
nearby traffic operations, shows clearance and information related to runway opera-
tions, warns pilot of runway conditions and turbulence from other operations,
warns when landing gear is not locked, displays the pilot emergency exits during
takeoff roll, shows the pilot when and where to exit from the runway, shows the pi-
lot where and when to cross a junction, calculates and displays pilot optimal speed
and timing on taxiways and junctions for saving fuel, calculates congestions, calcu-
lates best taxiway routes, calculates when aircraft can cross a runway, provides dis-
rectives and information to pilot over CPDLC display or dynamic Airport map for
airside operations, alerts and triggers breaks of the aircraft on wrong path or when
hold-short bar is breached, displays emergency personnel with routing map and fi-
nal aircraft resting position for emergency operations, takes over an aircraft opera-
tion when aircraft is hijacked or deviates from the flight plan, provide standalone or
manned Remote Tower functionality, Records and retains all information related to
airport airside operations including aircraft positions and conditions from sensors
and reports for runways, junctions and taxiways, Records and retains aircraft data
and cockpit voice to ground- based servers to eliminate black-box requirements,
calculate future weather and airport capacity from aircraft at or nearby airport, co-
ordinates handoff operations with other ATC positions, interfaces with ACDM sys-
tems, airport operations center, flow center and network operations center.
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CROSS REFERENCE TO RELATED APPLICATIONS

This document claims the benefit of the filing date of U.S. Provisional Application # 61755682, entitled system and methods for automated airport air traffic control services, which was filed on January 23, 2013, the disclosure of which is hereby incorporated entirely herein by reference.

FIELD OF THE INVENTION

The invention generally relates to the field of Traffic Control Systems for aircrafts and more particularly to Airport Tower Traffic control Systems combining control of both airborne and ground aircraft traffic.

BACKGROUND OF THE INVENTION

[0001] As Air/Ground infrastructures, standards and communication protocols for the aviation industry are being implemented by governing bodies such as EUROCONTROL (SESAR SWIM program) and FAA (NextGen program), emphasis is placed on the need for fully or partially automating ATC operations at or near airport areas, such reports include Flightpath 2050 (European commission) and, 2020 vision (CANSO).

[0002] In SESAR SWIM Master Class competition (June-October 2013), the system and partial embodied implementations were submitted to be reviewed by the judges, and have been registered within the EUROCONTROL SWIM registry since June/2013. Further acknowledgement of the said system title and embodied implementation, have been documented in several EUROCONTROL documents and, are in the process of further development or certification for standards or industrialization, including: the complete Automated Airport Air Traffic Control System (AAATCS), as well as additional standalone packages such as airport layout and status advisory (ALASAS), aircraft SWIM ATC module (ASAM), airport handoff departures coordinator (HADOC), contingency aircraft takeover system (CATS), SWIM data recorder (SDR) and, ACDM global gateway (AGG).

[0003] In addition, a development within the SESAR SWIM Master Class, included the dynamic airport map portion of the system, by using Honeywell air/ground infrastructure and simulated onboard computer device, has proved the market need and readiness for the system and embodiments. Large portions of the system and embodiments have already been developed and awaiting further testing and certification for industrialization.

[0004] The following discusses various aspects of Air Traffic Control (ATC) in airports within the scope of this invention, particularly in the areas of ATC operations relating to at or an airport or related to airport
operations. The aspects are discussed in the form of problems, with provided solutions within the scope of this invention.

[0005] First problem dealt with by the present disclosure relates to the large amount of repetitive and manual routine calculations, logic and operations performed by ATC, requiring constant awareness and high level of skill in adherence to rules, precision in timing and error-free multitasking, with low or no visibility to see out of the tower in severe weather and bad runway conditions and, the need to control and monitor multiple aircrafts with different operations or stages of flight, including holding short for a landing prior to lineup for takeoff, lining up for a takeoff on the runway, rolling for takeoff, aborting a takeoff, contacting departure, on a final approach for landing, Missed Approach or go-around, clearing the threshold area so another aircraft can line up for a takeoff, exiting or crossing the runway, moving and following and waiting on taxiways and taxiway crossings, closing and opening runways, dispatching emergency vehicles and personnel in case of emergency, closing and diverting aircraft in case of emergency or FOD clearing operations.

[0006] Second problem dealt with by the present disclosure is the inability of a tower ATC to remotely activate a go-around or missed approach procedure.

[0007] Third problem dealt with by the present disclosure is that pilots do not have complete and updated information related to their operation within an aerodrome.

[0008] Forth problem dealt with by the present disclosure is the inability to efficiently control an aircraft from the ground if it was hijacked or is off-course, or pilots lost control.

[0009] Fifth problem dealt with by the present disclosure is the dangers and safety issues resulting from call-sign similarities where Pilots execute ATC orders that were not directed to them, for example, ATC will issue "AC4554 follow company to 18L and hold short", but due to the similarity, the Pilot of AC4454 may mistakenly execute command. At times, the AC4454 aircraft will provide a read-back, and the AC4554 aircraft will assume the command was for AC4454. ATC does not always notice the read-back was from the wrong aircraft. There are three types of aircraft call-sign similarities. First type is a similar flight numbers for the same Airline operator, for example, AC4554 and AC4454. Second type is different airline operators with same or similar flight numbers, for example, AA4554 and AC4554, and third, is different airline operators with similar flight numbers, for example AA4554 and AC4454.

[0010] Sixth problem dealt with by the present disclosure is the time taken on the ATC frequency due to Pilot read-back operations. The time typically increases in two cases, first, when the flight-crew and ATC differ in speech, language or dialect, and second, when ATC provides many parameters within the ATC command to be repeated by the Pilot’s read-back. In most cases, Pilots typically request a “say again” and ATC will repeat either the whole command or some of the parameters, this increases the frequency time, time of ATC and Pilot by over thirty percent.

[0011] Seventh problem dealt with by the present disclosure is the limitation and congestion of runway ATC frequency due to the large amount of data given to flight crew during the clearance of a takeoff or landing, for example, ATC typically issues a landing clearance with wake turbulence advisory from previous aircraft
operation on the runway, winds, exit to take after the landing and the new ATC frequency for Ground ATC, and, possibly runway condition with reported breaking action during bad weather conditions.

[0012] Eighth problem dealt with by the present disclosure is the static nature of the information given by ATC during a takeoff and landing operation, which is not updated during the operation, for example, after an aircraft is issued a landing clearance by ATC with the wind direction and speed information during gusting wind conditions, the wind speed increases and the wind direction suddenly changes, the initial information given by ATC with the landing clearance is no longer valid and may become a hazard to aircraft safety.

[0013] Ninth problem dealt with by the present disclosure is the congestion of the ATC frequency for issuing routine runway exit instructions and ATC frequency change as the aircraft enters the area of another ATC. This also may include the different directives from the previous controller to the new controller, as each controller has their own mandate and way of controlling their area.

[0014] Tenth problem dealt with by the present disclosure is that any changes made by ATC after the clearance given at the gate force the flight crew to manually change the relevant onboard FMS [130] and/or CPDLC DU [140] to reflect any changes assigned by ATC, for example: the flight crew received a clearance at the gate to depart through a particular RNAV SID from a particular runway, but ATC reassigned a new runway for takeoff with a different departure RNAV, this situation forces the flight crew to re-enter data to the relevant FMS [130] and/or CPDLC DU [140], thus raising the probability of human error during the entry, lowering overall airport safety as the flight may be delayed on the runway and, directly affects nearby aircraft and related airport operations.

[0015] Eleventh problem dealt with by the present disclosure is the inability to automatically ground all airborne traffic and halt all airport operations in case of a terrorist attack or other security concern at any geographical area having air navigation service coverage.

[0016] Twelfth problem dealt with by the present disclosure if the aircraft the landing gear mechanism may not be locked prior to a landing, and, a controller may not be able to see or reliably assess from the tower if the landing gear is locked due to several visibility conditions and contributing factors, such as fog, smog, dust, low cloud formation, precipitation, brightness of the sun, or darkness at night.

[0017] Thirteenth problem dealt with by the present disclosure is when a runway closes due to a sudden emergency, and all landing traffic on final approach must be diverted to another runway or even another airport. In the event of an emergency, the controller workload is increased substantially, as many tasks must be performed, such as dispatching emergency vehicles and personnel to the area of incident, relaying the information to ground and arrival controllers to divert additional traffic to and from the runway. In addition, the controller must notify all aircraft on their final approach to execute a go-around or missed approach.

[0018] Fourteenth problem dealt with by the present disclosure is the large waste of fuel due to inefficient taxiway routes and waiting in intersections, changing taxi speeds and holding for takeoff on the runway.

[0019] Fifteenth problem dealt with by the present disclosure is the inability of maximizing the number of runway takeoff operations per runway due to human limitations in calculating the length or runway and time needed for a takeoff rollout for each aircraft type.
Sixteenth problem dealt with by the present disclosure is the issues of radio frequency jams created by unauthorized radio stations operating on the ATC radio frequency so neither ATC nor Pilots can efficiently talk on the frequency.

Seventeenth problem dealt with by the present disclosure is the inability to efficiently balance future takeoff operations between several runways.

Eighteenth problem dealt with by the present disclosure is that expedite instructions by ATC to pilots may not be executed by the pilot in time the controller expected it to be, whereby the expedite operation is affecting the overall safety of the area of the operation as well as other areas that may be related to that operation. This is the highest safety problems in airports today, especially related to runway crossing operations at very busy airports, as many incidents are registered at an alarming rate.

Nineteenth problem dealt with by the present disclosure is the information, notification and warnings given by ATC with a takeoff or landing clearance over the radio frequency. The information is only provided once and is not available to the flight crew at all times. In addition, the repetitive information such as winds, runway conditions and breaking action waste radio frequency time.

Twentieth problem dealt with by the present disclosure is the lack of situational awareness of a Pilot in regards to surrounding traffic and relevant airport operations that may affect the current or next operation. Pilots rely on what is being said on the over the radio frequency, and a combination of speed of speech and language barriers may reduce pilot situational awareness.

Twenty first problem dealt with by the present disclosure is the high manual workload involved in coordinating takeoffs between Tower and departures ATC positions, where each flight needs to be approved manually by the departures ATC prior to a takeoff clearance.

Twenty second problem dealt with by the present disclosure is the high manual workload of tower controller for compiling data from vast number of decision support tools and systems, to make a decision. In essence, the workload is reduced, but the time required to make a decision by a controller may take longer due to the number of inputs that are taken into account. As a direct result, a controller looks at the decision support screens more than before, and, less time is available to look at the conditions outside the tower. Also as a direct result, the controller will lose situational awareness of other aircraft traffic, and is one of the primary reasons in the ride of safety related incidents at airports in recent.

Twenty third problem dealt with by the present disclosure is the inability to control aircraft responding poorly to an expedite directive, or not fully clearing an intersection or junctions.

Twenty forth problem dealt with by the present disclosure is the time it takes for emergency vehicles to reach an emergency aircraft after a landing, whereby standards provide 5 minute response time, yet, smoke in an aircraft spreads in less than 2 minutes.

Twenty fifth problem dealt with by the present disclosure is the lack of information available to a pilot to make a go-around decision when the risk of overshooting the runway when over the TD too high and too fast, especially due to bad runway conditions and breaking action.
[0030] Twenty sixth problem dealt with by the present disclosure is the repetitive information given by tower controller to each departing or arriving aircraft, such as altimeter settings or winds.

[0031] Twenty seventh problem dealt with by the present disclosure is the inefficiency and incompleteness of the process of controller pilot negotiations of taxi routes between two points within an airport, as described in patents US08401775 and US 20100198489A1, it is also common for ATC to repeat the same process to multiple aircrafts within the same day that have to taxi from the same two points, such as several departing flights from the same terminal taxing to the same departing runway which is the most common scenario in most International airports.

[0032] Twenty eighth problem dealt with by the present disclosure is that FOD still requires the manual closure of a runway or taxiway by ATC, and traffic diverted, thus lowering the overall airport capacity.

[0033] Twenty ninth problem dealt with by the present disclosure is the lack of common interface between systems relating to aerodrome operations and related data.

[0034] Thirtieth problem dealt with by the present disclosure is that taxi route calculations do not provide the best possible taxi route between two points.

[0035] Thirty first technical dealt with by the present disclosure is that aircraft crossing junctions and runways may stop after the junction, while not completing the operation to be in a safe distance from the junction.


[0037] Thirty third deal with by the present disclosure is the lack of pilot situational awareness.

[0038] Thirty forth problem dealt with by the present disclosure is the lack of awareness and control a pilot has at or near the sleeve at the terminal gate. Relying on human ground personnel to provide with signals for thrusts and maneuvering. It is a known problem that the ground personnel make mistakes with several incidents that prove the need for a solution.

[0039] Thirty fifth problem dealt with by the present disclosure is inability to ground multiple airborne aircraft efficiently, in case of area emergency such as September 11.
Thirty sixth problem dealt with by the present disclosure is the workload and coordination efforts required to close a runway for maintenance, directly impacting overall airport capacity and operational delays.

Thirty seventh problem dealt with by the present disclosure is lack of pilot response time to ATC commands, lowering the airport capacity.

Thirty eighth problem dealt with by the present disclosure is lack situational awareness a pilot encounters within an airport during runway and taxi operations.

Thirty ninth problem dealt with by the present disclosure is lack information from an aircraft, especially regarding cockpit operations.

EXISTING ART

Clearances, requests and directives to pilots relating to airport movements operations, are only given or received by a human controller, although the communication may involve technologies of radio, data communication, CPDLC units for relaying information and alike, the human controller is the one that is making the decision and administrating the commands or providing the clearances.

Runway incursions, excursions, junction hotspots and taxiway transgression are currently well recognized as major safety issues at Airports. Runway incursions and taxiway transgression usually involve an inappropriate entry to a taxiway or runway and potentially can result in unsafe separation between other aircrafts or vehicles. As with any aviation accident or incident, the casual chain of events leading to runway incursions and unsafe taxiway transgression is complex. Current data shows that these events include consequences such as: takeoff or landing from a taxiway; takeoff or landing from incorrect runway; turning onto incorrect taxiway; unauthorized takeoff or landing; unauthorized runway crossing; unauthorized runway entry; and unauthorized taxiing. Many occurrences of these events involve poor Pilot approach or on-the-ground situational awareness that has not been overcome by either current traffic controls or Tower instructions. Furthermore, existing methods for selecting Runways and taxi routing are typically useless because they simply select the closest route without accounting for congestions and location of other aircrafts within the route.

Two different systems for implementing Controller Pilot Data Link Communications (CPDLC) for commercial aircraft today. The first CPDLC system is referred to as the Future Air Navigation System (FANS), or FANS CPDLC. FANS based programs are typically implemented on an aircraft's Flight Management Computer (FMC), also referred to as the Flight Management System (FMS), and communicate with Air Traffic Control (ATC) stations using text based messages communicated over the Aircraft Communications Addressing and Reporting System (ACARS). The second CPDLC system is implemented over the Aeronautical Telecommunication Network (ATN) via an aircraft's Communication Management
Function (CMF) and is commonly referred to as ATN CPDLC. It is typical to consider the CPDLC Display unit (DPDLCDU) as the interface for communicating with the Pilot.

Voice communication between ATC and pilots typically use radio frequency (RF) in the frequency range of 108MHz through 139MHz, the frequency range varies between geographical areas and countries. It is typical for each type of ATC operation to use a different frequency. It is typical to use a dedicated frequency for each area of the airport in an airport with many taxiways or more than one tower. It is also typical for a large airport or an airport with several runways to use a dedicated frequency for each runway or a set of runways. Two Types of ATC operations related to the movement of aircraft within an Airport, first, a Ground ATC, for moving aircraft to and from the runway via taxiways, and, second, a Runway ATC for all runway operations, including takeoff, landing and crossings. It is common to consider both types of ATC operations as a Tower ATC. In small airports, it is typical for one single ATC to perform both Ground ATC and Runway ATC operations.

One type of technology is used today by Airport ATC to communicate commands and information with Pilots. A Radio Frequency (RF) is used for voice communication between ATC and Pilots where both Pilots and the Controller speak on the same radio frequency.

Two types of CPDLC text messages are typically used in commercial aviation today. The first message type is a downlink, typically used for sending aircraft information to the ATC or Airline ground systems from the onboard FANS or FMS, typically the data contains aircraft operation data such as fuel level and route information. The second message type is a bidirectional link, typically used for communicating non-critical ATC messages between high-altitude ATC and the flight crew, typically over a CPDLC Display Unit, the data typically contains altitude, vector clearances or routing information. High-altitude ATC operations are typically known to be managed by a Centre or En-route ATC.

In the USA, CPDLC is being tested for texting messages for non-critical information or operations between ATC at Airports and Pilots.

Today, for checking if a landing gear is locked, the ATC notifies the Pilot over the ATC radio frequency after ATC looks with binoculars at the aircraft from the tower. Typically the landing gear check can only be done when there is good visibility conditions and good daylight conditions.

Today, when an emergency situation is dispatched to emergency personnel, the vehicles are routed strategically along runway points. The location of the vehicles is not always close to the final resting place of the aircraft, and sometimes may take the standard 5 minute response time to reach the aircraft.

Today, there are many tools, hardware and software products assisting ATC with information for decision support and increasing efficiency, however, humans remain as the highest probable cause for airport related safety incidents. The rate of incidents is rising due to capacity and controller workload conditions.

One type of controller protocol is used today for synchronizing departure requests between a Tower ATC with Departure ATC, a Tower ATC manually requests a "request-release" from departures ATC, and a flight will only be cleared for takeoff if a "released" is manually sent back from the departures ATC.
One type of technology is used today for sending information to pilots related to airport changes such as closed taxiways, are available as a recorded message, and the controller requests the pilot to know the changes, and the pilot acknowledges once he has heard the information by declaring “we have BRAVO”, the controller then knows the pilot understands the information and changes affecting the Airport.

Two types of technology are used today for ATC to assign taxi routes, One type is where an ATC verbally instructs a pilot of an aircraft to use a taxi route at an airport. The taxi route may be from any point within the airport to another. The second type is where an air traffic controller selects an aircraft on a display and assigns it a route, the route is then sent via uplink communication to onboard display, and the Pilot needs to confirm, reject or modify the sent route.

Many types of route and taxiway display apparatuses and schemes exist today, each providing certain information, or perspective, which are manually prescribed either by a controller or pilot, or provide partial functionality at best. Several types of common technologies provide some features, such as controller selected routes or segments, pilot approved and rejected routes, manual route or taxi entries, manual inputs, route selections, progressive taxi instructions, an airport map with perspective of the aircraft itself without other surrounding traffic or no map at all, nor the calculations for how long each route or route segment would take.

Currently, in order to ensure an aircraft is in a safe distance from or after clearing a junction or from other aircrafts, ATC informs the pilot on the radio frequency to stop or move the aircraft.

Today, communication of operational directives, clearances and information in International airports is done in English to bridge between all cultures and accents.

One type of technology is used today for providing operational information to pilots, depending on the operation, such as winds, crossing traffic, turbulence warnings, initial climb altitude, breaking action, birds, and alike.

Several types of technologies used today to control an aircraft if hijacked, one type of technology requires an onboard air marshal to switch off the autopilot and gain control back of the aircraft. Another type of technology contains several emergency routes to be executed by the autopilot.

Currently, lacking in the art is the full automation of Air Traffic Services for an Airport without the need for a human Controller to communicate with a pilot.
SUMMARY OF THE INVENTION

[0063] It is the main objective of this invention is to provide a standalone automated Air Traffic Control (ATC) system for managing airside operations at any airport or airfield or its nearby area, for all aircrafts and vehicles, by listening to pilots over the ATC radio frequency, communicating data to aircraft avionics and through CPDLC for Pilot interaction, or, through existing air/ground communication infrastructure with onboard computer via touch-screen or HUD while saying the commands and information through a speaker in pilot preferred language.

[0064] To ensure the primary objective of this invention met and as a requirement and result of other objectives, the second objective of this invention is to use ATC radio frequency for sending ATC voice commands to all aircrafts on the frequency, and recognizing Pilot’s voice for requests and responses to commands.

[0065] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the third objective of this invention is to provide automated information updates to a pilot during takeoff and landing operations in the form of text or pictures.

[0066] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the fourth objective of this invention is to identify and avoid congestions on taxiways, junctions and hotspots when assigning routing for taxiing to and from a runway.

[0067] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the fifth objective of this invention is to optimize runway and taxiway operations for lowering delays.

[0068] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the sixth objective of this invention is to maximize the number of takeoff operations for any long runway by allowing more aircrafts to safely takeoff from junctions instead of the initial lineup position at the start of the runway.

[0069] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the seventh objective of this invention is to automatically balance workloads of takeoff operations on multiple runways.

[0070] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the eighth objective of this invention is to allow Pilots to select preferred runways, runway exits and fastest routes for taxiing to and from runways.

[0071] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the ninth objective of this invention is to provide a notification to flight crew when the front landing gear is not locked prior to a landing operation.
[0072] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the tenth objective of this invention is to send control messages between the system and aircraft avionics. The Control Messages are used to both communicate with the flight crew and communicate with the avionics aboard the aircraft.

[0073] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the eleventh objective of this invention is to provide a system for triggering the autopilot of an aircraft and sending commands directly to the FMS for the aircraft to execute. The autopilot trigger is turned on in case of hijack, distress, or when aircraft deviates from its flight plan.

[0074] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twelfth objective of this invention is to provide an automated method to ground all airborne aircraft at any given airspace.

[0075] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirteenth objective of this invention is to use data communication for reducing the reliance of radio frequency as the primary medium for ATC services.

[0076] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the fourteenth objective of this invention is to automatically simultaneously manage and synchronize operations on multiple runways.

[0077] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the fifteenth objective of this invention is to automate the handoff operations with Ground ATC, Departure ATC and Arrivals ATC.

[0078] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the sixteenth objective of this invention is to automatically flash the runway lights to notify the Pilot of a landing aircraft when the Runway or airport is closed.

[0079] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the seventeenth objective of this invention is to automatically flash the runway exit lights for a landing aircraft to direct the Pilot where to exit and lower human errors. The flashing exit AFL[10] lights also operate at every taxiway junction.

[0080] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the eighteenth objective of this invention is to trigger aircraft breaks when an aircraft is taking a wrong turn at a junction or aircraft continues past a hold short bar. The objective can be induced automatically or manually by a Tower/Ground Controller.

[0081] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the nineteenth objective of this invention is to directly lower fuel costs during taxiway operations.

[0082] To ensure the primary objective of this invention is met and as a requirement or result of other objectives, the twentieth objective of this invention is to record and retain all data from all airport sensors, all image data from cameras located at or nearby the airport, all data and voice from cockpits of all aircraft at or nearby the airport that are normally sent to each aircraft's black-box, all commands and displayed images
onboard the dynamic moving map interface for each aircraft at or nearby the airport, all data displayed on CPDLC for each aircraft at or nearby the airport, all relevant data provided by external systems interacting with the system.

[0083] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty first objective of this invention is to allow Controllers to manage settings and preferences to be used by the system for preferred taxi routes, runway and airport capacity, emergency response, handoff with other controller positions and alike.

[0084] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty second objective of this invention is to warn a pilot to go-around when the landing aircraft may overshoot a runway due to current runway conditions, breaking action, aircraft altitude and speed.

[0085] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty third objective of this invention is to calculate future weather and associated airport capacity based on collected weather-related data from aircrafts systems at or nearby an airport.

[0086] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty forth objective of this invention is to notify emergency personnel of aircraft emergency situation with aircraft data and fastest route to take to the anticipated final resting position of the aircraft.

[0087] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty fifth objective of this invention is to re-route all aircrafts affected by emergency situation or hotspots or ground-traffic congestions to the best possible route for aircraft desired operation.

[0088] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty sixth objective of this invention is to share and interchange data with Airport collaborative decision making systems, Airport Operations Centers, Flow centers, ATM centers and network operation Centers.

[0089] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty seventh objective of this invention is to ensure the efficient selection of taxi routes to and from different locations within an airport.

[0090] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty eighth objective of this invention is to communicate data with other external systems by using system embodiments and implementations to standards in protocols and framework for data interchange set by EUROCONTROL SESAR SWIM framework and alike.

[0091] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the twenty ninth objective of this invention is to control the engines and steering of the aircraft when the pilot has not cleared the junction for other safe operations, where the system will communicate to the aircraft power controls and steering controls and break control system, to produce the proper power and steering and break combination required for the aircraft to be in safe distance from the junction.

[0092] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirtieth objective of this invention is to provide a pilot a selection list of available routes, with
time for each route, with optional progressive taxiing, or a complete taxi route. All options will include estimated total time for taxi to destination from current location.

[0093] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty first objective of this invention is to provide a pilot better situational awareness and overall airport safety, through the display of distance until a junction, or a turn to be taken.

[0094] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty second objective of this invention is to provide a pilot better situational awareness through the ability to set measurement preferences for distances, speeds and alike, such as meters and feet, km and miles, kph and mph, and alike.

[0095] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty third objective of this invention is to provide a pilot better situational awareness through the ability to set a view or satellite image of the airport, or an airport diagram, as some pilots are more oriented to satellite images.

[0096] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty forth objective of this invention is to provide a pilot better situational awareness and increase security within designated areas, provide a visual and audible warning to the pilot when in the direction nearing a restricted airport area. If the aircraft is too close and remains on course to the restricted area, security personnel are dispatched and a warning is also displayed and heard by the administrating tower controller.

[0097] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty fifth objective of this invention is to provide a pilot better visual representation of the surface and gate sleeve to make better gate maneuvering decisions during taxi operations such as pushback and alike.

[0098] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty sixth objective of this invention is to reduce operating costs for air navigation service operators, associated in direct costs of highly skilled labor, training and system overheads, by reducing the amount of controller workload, and thus reduce the number of controllers needed at the tower at any given time.

[0099] To ensure the primary objective of this invention is met and as a requirement and result of other objectives, the thirty seventh objective of this invention is to provide all airside personnel and vehicles with a handheld device, providing personnel the same functionality for maximized situational awareness and taxi routing, with the additional functionality of requesting to a maintenance window or to immediately close or open any runway, taxiway, junction or area for maintenance or security reasons, such as debris removal and replacing airfield lights.

[0100] The system includes a Server [300], Landing Gear Reporting Cameras (LGRC) [355], Aircraft Position Reporting Sensors (APRS) [353] and movement detection cameras (MDC) [354]. In addition, the computer programs associated with the system include an Airport Management Software (AMS) [320], an
Interactive Controller Module (ICM) [330], Emergency Dispatch Module (EDM) [331] with an Emergency Announcement System (EAS) [340], and, a Strategic Airline Monitoring Module (SAMM) [339].

[00101] The system uses the following equipment and technologies for communicating with aircrafts and Pilots: a wireless communication link (WCL) [600]; ground-based communication equipment (GBCE) [310]; aircraft CPDLC communication unit [110]; aircraft FANS communications unit [120]; aircraft Flight Management System (FMS) [130]; aircraft CPDLC Display Unit (CPDLCU) [140]; an aircraft Autopilot [150]; various Aircraft Position Reporting Devices (APRD) [350] including: input from external systems, Radar [351] and GPS [352]. In addition the said CPDLCU [140] and related infrastructure embodiment and implementation, another embodiment of the system may also use equipment and infrastructure consisting of a Dynamic Airport Map Software (DAMS) [161] executed on a Cockpit Computer System (CCS) [160] to provide seamless bidirectional interface between Pilot and flight crews with the AMS [320] via DAMS [161] running on CCS [160] linked via existing Air/Ground communication infrastructures [610], such as SITA, Honeywell, HARRIS, and alike.

BRIEF DESCRIPTION OF THE DRAWINGS

[00102] FIG. 1 is a perspective view of the hardware, computers and devices used by the system, in accordance with an example embodiment.

[00103] FIG. 2 is a diagram that further illustrates the uplink and downlink data flow between the Server [300] and each of the communication systems aboard the aircraft [100], in accordance with an example embodiment.

[00104] FIG. 3a illustrates a flow diagram of the processes in a method within the AMS [320] involved in sending a Control Message to FANS or FMS or CPDLCU [140] for processing, in accordance with an example embodiment.

[00105] FIG. 3b illustrates a flow diagram of the processes in a method within the AMS [320] involved in sending a Control Message to DAMS [161], in accordance with an example embodiment.

[00106] FIG. 4 illustrates a block diagram of the data communication in methods involved in sending a Control Message between the AMS [320] and the various onboard aircraft equipment [110,120,130,140,150], in accordance with an example embodiment.

[00107] FIG. 5 lists an example of Control Messages sent to the aircraft [100] by the AMS [320], in accordance with an example embodiment. The example embodiment showing CPDLCDU [140] also refers to control messages supported by DAMS [161].

[00108] FIG. 6 lists an example of incoming Control Messages sent from the various onboard aircraft equipment [110,120,130,140,150,160] to the AMS [320], in accordance with an example embodiment. The example embodiment showing CPDLCDU [140] also refers to control messages supported by DAMS [161].
FIG. 7 lists an example of ATC commands processed by the AMS as voice commands over the ATC radio frequency, in accordance with an example embodiment.

FIG. 8 illustrates an example of locations for all types of Aircraft Position Reporting Device (APRD) [350], Movement Detection Cameras (MDC) [354] and Landing Gear Reporting Cameras (LGRC) [355] in relation to a Runways and taxiways, used by the AMS for updating the aircraft locations database [1010], in accordance with an example embodiment.

FIG. 9 illustrates an example of network topology for an Airport with Server [300] connectivity with ICM [330], EDM [331] and SAMM [339], in accordance with an example embodiment.

FIG. 10 illustrates the relationships between the various databases used by AMS, in accordance with an example embodiment.

FIG. 11 illustrates a flow diagram of the processes in a method within the AMS involved in issuing a "lineup and wait" ATC command to an aircraft, in accordance with an example embodiment.

FIG. 12 illustrates a flow diagram of the processes in a method within the AMS involved in issuing a takeoff clearance ATC command to an aircraft, in accordance with an example embodiment.

FIG. 13 illustrates a flow diagram of the processes in a method within the AMS involved in issuing a landing clearance ATC command to an aircraft, in accordance with an example embodiment.

FIG. 14 illustrates a flow diagram of the processes in a method within the AMS involved in updating CPDLCDU or DAMS while an aircraft is rolling during a takeoff operation with the possibility the takeoff will be aborted, in accordance with an example embodiment.

FIG. 15 illustrates a flow diagram of the processes in a method within the AMS involved in updating CPDLCDU or DAMS while an aircraft is breaking during a landing operation, in accordance with an example embodiment.

FIG. 16 illustrates a flow diagram of the processes in a method within the AMS involved with managing a Go-Around or Missed Approach, in accordance with an example embodiment.

FIG. 17 illustrates a flow diagram of the processes in a method within the AMS involved with accepting an aircraft handoff from Approach ATC, in accordance with an example embodiment.

FIG. 18 illustrates a flow diagram of the processes in a method within the AMS involved with an aircraft handoff operation to Departure ATC, in accordance with an example embodiment.

FIG. 19 illustrates a flow diagram of the processes in a method within the AMS involved with automatically accepting an aircraft handoff from Ground ATC, in accordance with an example embodiment.

FIG. 20 illustrates a flow diagram of the processes in a method within the AMS involved with an aircraft handoff operation to Ground ATC, in accordance with an example embodiment.

FIG. 21 illustrates a flow diagram of the processes in a method within the AMS involved in Timing runway crossings during landing operations, in accordance with an example embodiment.

FIG. 22 illustrates a flow diagram of the processes in a method within the AMS involved in simultaneously managing multiple runway operations, in accordance with an example embodiment.
FIG. 23 illustrates a flow diagram of the processes in a method within the AMS [320] involved with predicting taxiway congestion and hotspots, in accordance with an example embodiment.

FIG. 24 illustrates a flow diagram of the processes in a method within the AMS [320] involved in avoiding congested taxiways and hotspot crossings when assigning routing to and from a runway, in accordance with an example embodiment.

FIG. 25 illustrates a flow diagram of the processes in a method within the AMS [320] to maximize takeoff operations on long runways, in accordance with an example embodiment.

FIG. 26 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a turbulence advisory during landing or takeoff clearance, in accordance with an example embodiment.

FIG. 27 illustrates a flow diagram of the processes in a method within the AMS for displaying ATC commands and allowing Pilot confirmation through the CPDLCDU [140] or DAMS [161], in accordance with an example embodiment.

FIG. 28 illustrates a flow diagram of the processes in a method within the AMS [320] to automatically recognize and reply to Pilot requests over ATC voice frequency, in accordance with an example embodiment.

FIG. 29 lists an example of the recognized Pilot requests and responses over existing ATC voice frequency supported by the system, in accordance with an example embodiment.

FIG. 30 illustrates the location of the exit flashing AFL[10] light to notify a Pilot where to exit the runway, in accordance with an example embodiment.

FIG. 31 illustrates the location of the closed runway flashing AFL[10] lights to notify Pilots of a closed runway, in accordance with an example embodiment.

FIG. 32 illustrates a flow diagram of the processes in a method within the AMS [320] to dispatching emergency personnel when the Landing Gear is not locked, in accordance with an example embodiment.

FIG. 33 lists the types of CPDLCDU [140] screens available to the Pilots and flight crews sent from the AMS [320], in accordance with an example embodiment. The example embodiment showing CPDLCDU [140] also refers to control messages supported by DAMS [161].

FIG. 34a illustrates an example output of the onboard CPDLCDU [140] related to a "hold short" ATC directive on a runway prior to a takeoff clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 34b illustrates an example pilot interface of the onboard DAMS [161] related to a "hold short" ATC directive on a runway prior to a takeoff clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 35a illustrates an example output of the onboard CPDLCDU [140] related to a "lineup and wait" ATC directive on a runway prior to a takeoff clearance to a specific aircraft, in accordance with an example embodiment.
FIG. 35b illustrates an example pilot interface of the onboard DAMS [161] related to a "lineup and wait" ATC directive on a runway prior to a takeoff clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 36a illustrates an example output of the onboard CPDLCDU [140] that shows a generated ATC command and related information for a takeoff clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 36b illustrates an example pilot interface of the onboard DAMS [161] that shows a generated ATC command and related information for a takeoff clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 37a illustrates an example output of the onboard CPDLCDU [140] during the takeoff roll of an aircraft, in accordance with an example embodiment.

FIG. 37b illustrates an example pilot interface of the onboard DAMS [161] during the takeoff roll of an aircraft, in accordance with an example embodiment.

FIG. 38a illustrates an example output of the onboard CPDLCDU [140] after the aircraft is airborne, in accordance with an example embodiment.

FIG. 38b illustrates an example pilot interface of the onboard DAMS [161] after the aircraft is airborne, in accordance with an example embodiment.

FIG. 39a illustrates an example output of the onboard CPDLCDU [140] that shows a generated ATC command and related information for a landing clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 39b illustrates an example pilot interface of the onboard DAMS [161] that shows a generated ATC command and related information for a landing clearance to a specific aircraft, in accordance with an example embodiment.

FIG. 40a illustrates an example output of the onboard CPDLCDU [140] that shows the update sent by the AMS[320] for a breaking operation of a landing aircraft, in accordance with an example embodiment.

FIG. 40b illustrates an example pilot interface of the onboard DAMS [161] that shows the update sent by the AMS[320] for a breaking operation of a landing aircraft, in accordance with an example embodiment.

FIG. 41a illustrates an example output of the onboard CPDLCDU [140] that shows the information displayed during a Missed Approach, in accordance with an example embodiment.

FIG. 41b illustrates an example pilot interface of the onboard DAMS [161] that shows the information displayed during a Missed Approach, in accordance with an example embodiment.

FIG. 42a illustrates an example output of the onboard CPDLCDU [140] that shows the information displayed for a Go-Around operation, in accordance with an example embodiment.

FIG. 42b illustrates an example pilot interface of the onboard DAMS [161] that shows the information displayed for a Go-Around operation, in accordance with an example embodiment.

FIG. 43a illustrates an example output of the onboard CPDLCDU [140] that allows flight crew to request a runway exit from a list of exits, in accordance with an example embodiment.
FIG. 43b illustrates an example pilot interface of the onboard DAMS [161] that allows flight crew to request a runway exit from a list of exits, in accordance with an example embodiment.

FIG. 44 illustrates an example output of the onboard CPDLCDU [140] that allows flight crew to select a routing from a list of routes, in accordance with an example embodiment.

FIG. 45 illustrates an example output of the onboard CPDLCDU [140] that allows the flight crew to report a runway breaking action, in accordance with an example embodiment.

FIG. 46 illustrates an example output of the onboard CPDLCDU [140] that allows the flight crew to report runway conditions, in accordance with an example embodiment.

FIG. 47 illustrates an example output of the onboard CPDLCDU [140] that allows the flight crew to report bird activity, in accordance with an example embodiment.

FIG. 48 illustrates an example output of the onboard CPDLCDU [140] that allows the flight crew to report debris on runway, in accordance with an example embodiment.

FIG. 49a illustrates an example of the onboard CPDLCDU [140] menu, in accordance with an example embodiment.

FIG. 49b illustrates an example of the onboard DAMS [161] menu, in accordance with an example embodiment.

FIG. 50 illustrates a flow diagram of the processes in a method within the AMS [320] involved with a Pilot runway exit request, in accordance with an example embodiment.

FIG. 51 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating breaking speeds and runway exits while an aircraft is landing or aborting a takeoff, in accordance with an example embodiment.

FIG. 52 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating aircraft progress on a taxiway, in accordance with an example embodiment.

FIG. 53 illustrates a flow diagram of the processes in a method within the AMS [320] involved with a Request Release operation from Departure ATC, in accordance with an example embodiment.

FIG. 54 illustrates a flow diagram of the processes in a method within the AMS [320] involved with determining if an aircraft cleared a junction, in accordance with an example embodiment.

FIG. 55 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating junction congestions and hotspots levels, in accordance with an example embodiment.

FIG. 56 illustrates a flow diagram of the processes in a method within the AMS [320] involved in LGRC [355] image processing for confirming locked gear of a landing aircraft, in accordance with an example embodiment.

FIG. 57 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a "hold short" ATC command to an aircraft, in accordance with an example embodiment.

FIG. 58 illustrates a flow diagram of the processes in a method within the AMS [320] involved with runway capacity balancing and takeoff to landing ratios, in accordance with an example embodiment.
FIG. 59 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of breaking action, in accordance with an example embodiment.

FIG. 60 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of runway conditions, in accordance with an example embodiment.

FIG. 61 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of birds, in accordance with an example embodiment.

FIG. 62 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of debris on a runway, in accordance with an example embodiment.

FIG. 63 illustrates a flow diagram of the processes in a method within the AMS [320] involved with taking over an aircraft and activating the autopilot [150], in accordance with an example embodiment.

FIG. 64 illustrates a flow diagram of the processes in a method within the AMS [320] involved with grounding all airborne aircrafts, in accordance with an example embodiment.

FIG. 65 lists the codes for common terms used within the patent application.

FIG. 66 illustrates a flow diagram of the processes in a method within AMS [320] for filtering and merging of data from multiple sources and producing a dynamic airport map for each aircraft with its own relevant map view, information and menu options, and, sending it to DAMS[161] to be displayed to pilot.

FIG. 67 illustrates a flow diagram of the processes in a method for triggering the breaks of an aircraft taking a wrong turn or passing the hold-short bar.

FIG. 68 illustrates a flow diagram of the processes in a method for marshalling of aircraft steering and engine power for maneuverability within the airport

FIG. 69 illustrates the interface with a moving airport diagram instead of an airport map

FIG. 100 illustrates a block diagram for supported protocols, data interchange models and frameworks to support common requirements and standards such as EUROCONTROL SESAR SWIM and FAA NextGen.

FIG. 101 illustrates a flow diagram of the processes in a method within the DAMS [161], involved in processing a Control Message and sending it to AMS [320] to in accordance with an example embodiment

FIG. 102 illustrates a flow diagram of the processes in a method within the DAMS [161], involved in processing a pilot voice as a Control Message and sending it to AMS [320] to in accordance with an example embodiment.

Fig. 103 illustrates an example of the process used in recording and storing avionics data as well as cockpit sounds.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the
following detailed description. The detailed description refers to elements or features being "connected" or "coupled" together. As used herein, unless expressly stated otherwise, "connected" means that one element/feature is directly joined to (or directly communicates with) another element/feature, and not necessarily mechanically. Likewise, unless expressly stated otherwise, "coupled" means that one element/feature is directly or indirectly joined. In order to increase clarity, example embodiments are described with reference to the following drawings, where like numerals refer to like elements throughout. Furthermore, well-known features that are not necessary for the understanding of the example embodiments may not be shown in the illustrations, block diagrams and flow diagrams within the figures are merely illustrative and may not be drawn to scale. In order to emphasize certain features, the drawings may not be to scale. It should be understood that although two elements may be described below, in one embodiment, as being "connected," in alternative embodiments similar elements may be "coupled," and vice versa. Thus, although the diagrams shown herein depict example arrangements of elements, additional intervening elements, devices, features, or components may be present in an actual embodiment. The illustrations, drawings, flowcharts and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of Systems, hardware, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of program code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based Systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular form "a", "an" and "the" and "with" and "or" are intended to include the plural form as well, unless the context clearly indicates otherwise. It will be further understood that for clarity of explanation within the invention, the term "process" may refer to the term "method" and/or state and/or an event within the method itself. It will be further understood that the term "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As will be appreciated by one skilled in the art, the disclosed subject matter may be embodied as a System, method or computer program product. Accordingly, the disclosed subject matter may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "System." Furthermore, the present invention may take the form of a computer
program product embodied in any tangible medium of expression having computer-usable program code embodied in the medium. Any combination of one or more computer usable or computer readable medium(s) may be utilized. The computer usable or computer-readable medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor System, apparatus, device, or propagation medium including a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CDROM), a portable pluggable device (USB), an optical storage device, a transmission media such as those supporting the Internet or an intranet, electrical connection with one or more wires, a local area network connection (LAN), a wide area wireless network connection (WAN), or a magnetic storage device. Note that the computer-usuable or computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning or photographic device with optical character recognition (OCR) processing abilities of the paper or other medium, then compiled, interpreted, or otherwise processed in a suitable manner, if necessary, and then stored in a computer memory. In the context of this document, a computer-usuable or computer-readable medium may be any medium that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution System, apparatus, or device. The computer-usable medium may include a propagated data signal with the computer-usable program code embodied therewith, either in baseband or as part of a carrier wave. The computer usable program code may be transmitted using any appropriate medium, including but not limited to wireless, wire, optical fiber cable, RF, Satellite, Cellular network, Microwave transmissions and the like.

Computer program code for carrying out operations of the present invention may be written in any combination of one or more programming languages, including an object oriented or procedural programming language or script-enabled language such as C, C++, Pascal, Python, Visual Basic, Perl, Delphi, SQL, lisp, Matlab or the like. The program code may execute entirely or partially, as a stand-alone package, or a program or module or service, on any computer hardware type such as a Server or on any computer or airborne device such as CPDLC [110] or FANS [120] or FMS [130]. Any Server or computer or airborne device such as CPDLC [110] or FANS [120] or FMS [130] may be connected to any other Server or computer or airborne device such as CPDLC [110] or FANS [120] or FMS [130] through any type of network, including a local area network (LAN) or a wide area network (WAN), RF, satellite, or any type of Air Traffic Network (ATN) protocol support for transferring data for the Aircraft industry. The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. The embodiment was chosen and described in order to best explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to
understand the invention for various embodiments with various modifications as are suited to the particular or any use contemplated.

[0119] To increase the clarity of the invention, it should be understood that the system is comprised of multiple methods, hardware, software package and embodiments, and therefore all methods and hardware and software package and embodiments should be assumed to rely and be "connected" or "coupled" to at least one or more method or hardware or software package or embodiment within the system, to comprise the AAATCS as an operable and industrialized system. To further increase the clarity and readability of the invention, terms with numerical reference are listed numerically in FIG. 65, and, the following terms are used within the description, figures, illustrations, diagrams, claims and embodiments of the invention application:

AAATCS refers to the patent application for a system known as Automated Airport Air Traffic Control System with Flight Takeover. Control Messages (CM) refer to all message types including but not limited to control messages, image data of all formats, binary data, text messages, ASCII codes, weather maps, statuses, whereby the Messages and Control Messages are both used throughout the invention for ease of reading, and mean the same Control Message (CM). To further increase the clarity and readability of the invention, the terms cockpit and flight-deck, or deck, are interchangeable and mean the same cockpit, and unless specified otherwise, it applies to all devices, equipment, display, displays, crew, crew members and pilots. Aircraft [100] refers to any transport vehicle allowed within a controlled aerodrome, able to change altitude and is controlled either by a person or persons within the object, or controlled remotely by a person or persons, or, is controlled by an onboard computer, including but not limited to aircraft, helicopter, unmanned-vehicle (UAV), air balloon, shuttle, airborne vehicle, reusable rocket, glider and alike. Server [300] refers to any computer hardware device allowing execution of programs, modules and services on an operating system without the need of human interaction, while allowing connections to and from computers and electronic devices over a network of either wired or wireless connections. Airport, refers to any authorized designated area for aircraft [100] takeoff and landing operations. Airfield lights [10] refers to any controllable lighting system. Tower [20], refers to any control facility providing Air Traffic Control services for an Airport and nearby area. Taxiway refers to any road aside from the runway within an airport, authorized for the movement of aircraft [100]. Runway refers to any road or area designated for aircraft [100] takeoff and landing operations. Ramp, refers to any area designated for the parking of aircraft [100], including deicing area. Gate, refers to any area within a Terminal area where an aircraft is not in movement. Terminal refers to any building and nearby area where several aircraft either did not start the flight or completed their flight. Radar [351] refers to any electronic device and/or computer software with output of Aircraft Position information received from an aircraft radar device, in the form of data, including flight number, longitude, latitude, altitude, speed and direction. GPS [352] refers to any electronic device and/or computer software with output of Aircraft position information received from a satellite, in the form of data, including flight number, longitude, latitude, altitude, speed and direction. Aircraft Position Reporting Sensors (APRS) [353] refer to any electronic device with an output signal when an aircraft [100] is detected in its range. Movement detection camera (MDC) [354] refers to any digital camera device sending image data to the AMS [320] for
processing position information of an aircraft [100] from the image. ACARS refers to a wireless ground-air communication protocol and data link known as Aircraft Communications Addressing and Reporting System, allowing text messages to be communicated between controllers and onboard equipment. ATN refers to a wireless ground-air communication protocol and data link known as Aeronautical Telecommunication Network, allowing text messages to be communicated between controllers and onboard equipment via an aircraft's Communication Management Function (CMF). FMS [130] refers to the Flight Management System aboard an Aircraft, responsible for managing the flight operations including altitude, speed direction and routing. FANS [120] refers to an onboard communication protocol and data link known as the Future Air Navigation System, where ACARS communication protocol is used to communicate messages between controllers and the FMS [130] onboard the aircraft [100]. CPDLC [110] refers to a wireless ground-air communication protocol and data link Controller Pilots Data Link Communications for exchanging text-based messages between controllers and pilots. CPDLC DU [140] refers to the CPDLC Display Unit aboard an aircraft [100], allowing pilots to see text messages sent by controllers from the ground and send back messages to the controller on the ground. Heads-up display (HUD) refers to glass-display, or touch-based glass-display hardware in cockpit for graphical display and bidirectional interaction of messages related to aircraft operations, between pilots and AMS [320] via CCS [160], running DAMS [161]. Cockpit Computer System (CCS) [160] refers to computer hardware within the cockpit or UAV operator consul with human interface using a touch-screen or a HUD, and, communicating messages between AMS [320] and DAMS [161]. Dynamic Airport Map Software (DAMS) [161] refers to a software, executed on the CCS [160], to interact functionality and messages between the AMS [320]. Landing Gear Reporting Cameras (LGRC) [355] refers to any digital camera device sending image data to the AMS [320] to process the image and identify when the Landing Gear of a landing aircraft [100] is not locked prior to the touchdown. Aircraft Position Reporting Device (APRD) [350] refers to any electronic device able to report any type of Aircraft Position, including longitude, latitude, altitude, speed, direction, or location on a runway or location on a taxiway. Typically, (APRS) [353] and (MDC) [354] or associated computer programs report aircraft location within the airport or airfield, while radar [351] and GPS [352] or associated computer programs report aircraft longitude, latitude, altitude, speed and direction. Control Message (CM) refers to a text message sent from the ground in order to control aircraft operations, a Control Message is sent by the AMS [320] on the Server [300] through the GBCE [310] using the WCL [600] or AGC [610] to the onboard FANS [120] or FMS [130] or CPDLC [110], to control the autopilot [150] or, to display messages and interact with the flight crew via the CPDLC DU [140]. Emergency Announcement System (EAS) [340] refers to the broadcasting system sounding an alarm within an emergency facility such as a fire station or ambulance station. RF refers to any radio frequency used as ATC frequency for voice communication between a controller and pilots, and/or between two or more controllers and/or between controller and emergency personnel. Autopilot [150] refers to the automated flying mechanism of an aircraft [100] based on onboard FMS [130]. SATCOM refers to any satellite communication protocol or data link, primarily used for retaining longitude, latitude, altitude, speed and direction of aircraft. To allow for easier understanding of the invention, instead of referring to equipment
communication links and protocols for ACARS, FANS [120], ATN CMF, RF, SATCOM CPDLC [110] individually, ground-based communication equipment (GBCE) [310] refers to all above communication equipment types as a single communication equipment, and, wireless communication links and protocols (WCL) [600], refers to all above communication link and protocol types as a single communication link and protocol. Air/Ground Communication (AGC) [610] refers to existing communication infrastructure and protocols allowing for aviation data interchange between any software or system on the ground, with any software or system aboard an aircraft that comply with SESAR or NEXTGEN or SWIM data interchange guidelines, such as AMQP, HTTPS and alike. Hand gesture sensing hardware (HAGSH) [311] refers to sensory hardware attached to a computer instead of a mouse, such as Microsoft kinnect or Leap Motion, or alike, allowing a computer user to move hands in the air and achieve same functionality as a mouse or touchscreen. Airport Management Software (AMS) [320] refers to the computer program responsible for the AAATCS. Controller Module (ICM) [330] refers to a computer program allowing ATC personnel to interact and manage the AAATCS either by data entry, mouse or by hand gestures and using HAGSH [311]. Emergency Dispatch Module (EDM) [331] refers to a computer program allowing emergency and security personnel to view information and interact with the software regarding emergency situations within the airport or airfield either by data entry, mouse or by hand gestures and using HAGSH [311]. Airport Operations Center Module (AOCM) [333] refers to a computer software running on a workstation connected on a network with the AMS [320] to allow airport operations center personnel to visualize and manage airport operations, capacity and queues on runways taxiways, junctions and hotspots, either by data entry, mouse or by hand gestures and using HAGSH [311]. Airport collaboration decision making (ACDM) [334] refers external network infrastructure of computers connected over a network to the Server [300], and exchanging aircraft and airport scheduling with the AATCS. Automated handoff coordinator (HADOC) [335] refers to a computer software running on a workstation connected on a network with the AMS [320] to allow any arrivals or departure controller to visualize and manage related associated airport automated operations related to position tasks either by data entry, mouse or by hand gestures and using HAGSH [311], including handoffs, slotting, halt departures and arrivals, coordinate emergency situations to be dispatched by the AAATCS. Air traffic management software (ATMS) [336] refers to a computer software running on a workstation connected on a network with the AMS [320] to allow Flow control and network operations personnel to visualize and manage overall airport flow capacity, halt all ground-traffic, departures and arrivals, either by data entry, mouse or by hand gestures and using HAGSH [311]. Strategic Airline Monitoring Module (Samm) [339] refers to a computer program allowing airlines to communicate with the Pilot via CPDLCDU [140] or DAMS [161] and exchange information and Control Messages with the onboard FANS [120], FMS [130] and autopilot [150]. "Line-up and wait" or "position and hold" and alike, refer to commands given by ATC to prepare an aircraft for takeoff on the runway and wait for a takeoff clearance. "Missed Approach" or "Go Around" and alike refer to procedures where a landing aircraft needs to climb in altitude instead of land. "Unable" refers to a response where a flight crew or controller is unable to comply with a request or command. "Say again" refers to a request over ATC frequency to repeat the last communication. "Read-back"
is an operation typically performed by a flight crew whereby the flight crew repeats the command given by ATC as a confirmation. Flight crew refers to at least one Pilot or person aboard an aircraft, qualified to operate the aircraft.

Furthermore, To increase the clarity of the invention and understanding of the drawings diagrams and flow charts, when describing communication or Control Messages between AMS [320] and the CPDLCDU [140] or the autopilot [150], it is to be understood the communication or Control Messages are sent via the Server [300] through the proper WCL [600] to the proper avionics (FANS[120] or FMS [130]) to communicate or relay the endpoint AMS [320] and the CPDLCDU [140], and vice versa when endpoint AMS [320] and the CPDLCDU [140] sends or receives Control Messages with the AMS [320]. When describing communication or Control Messages between AMS [320] and the DAMS [161], and vice versa when endpoint AMS [320] and the DAMS [161] sends or receives Control Messages with the AMS [320] via CCS [160] through the AGC [610]. The above are explained within FIG. 2 for the data communication flow and FIG. 4 for communication of Control Messages.

First technical solution is to automate routine airport ATC operations, specifically runway and taxiway related operations. This automation is achieved by the said AAATCS patent application as shown in FIG. 1, comprising a Server [300] executing Airport Management Software [320], to process and communicate ATC voice commands over ATC radio frequency (RF) and, concurrently communicate data via a wireless communication link (WCL) [600] through the ground-based communication equipment (GBCE) [310] with onboard aircraft [100] CPDLC communication unit [110] and onboard FANS [120], to provide messages and commands in the form of data and, The CPDLC communicates commands and data with the flight crew via the CPDLCDU [140], and, the FANS [120] exchanges commands, data and control messages with both the onboard (FMS) [130], and with the Autopilot [150]. Reporting equipment [350] including Radar [351], GPS [352], Aircraft Position Reporting Sensors (APRS) [353], movement detection cameras (MDC) [354] and Landing Gear Reporting Cameras (LGRC) [355] are attached to the Server [300] on a secure network from various airport locations. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

Second technical solution is to present a new type of ground-air communication protocol allowing ATC to send control messages to the aircraft for execution. The communication protocol is an uplink allowing an ATC to send Control Messages from the ICM [330] via AMS [320] to the FANS [120] and/or FMS [130] for execution. The control messages for execution vary based on the operation, location and state of the aircraft. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

Third technical solution is to allow the flight crew to see and respond to airport related ATC messages, commands, data and options through the onboard CPDLCDU [140] via the FANS [120] and/or the FMS [130] to and from a Server actively executing an Airport Management Software (AMS) [320].
reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0124] Forth technical solution is to automatically, or allow ATC to manually activate the autopilot [150] and overtake any aircraft by sending a Control Message from the ICM [330] via AMS [320] to the FANS [120] and/or FMS [130] to turn on the autopilot [150] and disable it from being turned off from within the aircraft [100]. ICM [330] notifies ATC of the situation by an alert sound and message, and allows ATC to manage the aircraft [100] and turn the autopilot [150] on and off. In addition, ICM [330] allows ATC or the Airline to send a new flight-plan to the FANS [120] and/or FMS [130] and redirect the aircraft [100] using the autopilot [150] to any particular route and landing location. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0125] Fifth technical solution is to provide the Control Message only to the relevant aircraft on the CPDLCDU [140] for the flight crew. The Control Message is sent by the AMS [320] to the CPDLC [110] aboard the aircraft and displays the data on the CPDLCDU [140]. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0126] Sixth technical solution is to allow for the pilot to select "ACCEPT" and "UNABLE" options on the CPDLCDU [140] for all airport-related ATC commands, messages and data. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0127] Seventh technical solution is to show the flight crew all the data related to the operation on the AMS [320] send all the additional relevant information needed for the takeoff or landing operation to the CPDLCDU [140] for the flight crew to see, thus lowering the congestion on the ATC radio frequency, and making the information available for the flight crew during the full operation without the need to remember it. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0128] Eighth technical solution is to refresh and show the flight crew all the data related to the landing or takeoff operation as the data changes on the CPDLCDU [140], for example, as the wind direction and/or speed changes, the information is refreshed every time on the CPDLCDU [140] for the pilot to see with a sign showing there are changes since the initial data was given, this provides the flight crew with important update to make the necessary changes for the landing or takeoff operation. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding
the specification and example embodiments address these as well as other issues associated with the related art.

[0129] Ninth technical solution is to show the flight crew all the data related to the exit operation on the CPDLC in real-time with the frequency to switch to. In addition, the AMS, flashes the lights of the closest taxiway to exit, thus allowing aircraft to use the proper exit without mistakes in low visibility where the exits illumination is unclear, and thus allowing more runway operations in a safe manner. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0130] Tenth technical solution is to automatically send the new departure data to the relevant onboard FMS [130] and/or CPDLCDU [140], while displaying the flight crew with the notification of the change made on the CPDLCDU [140]. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0131] Eleventh technical solution is to simultaneously send all airborne aircrafts near any selected airport, area, country or continent an immediate flight-plan to follow as if it was hijacked, thus, grounding all airborne aircraft in the most efficient manner. This operation is possible since all airports with AMS [320] are interconnected on a network, and allows alerting controllers through ICM [330] at all relevant airports with AMS [320] of the situation immediately and automatically. This substantially lowers the workload of all controllers dealing with the grounding of the aircrafts. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0132] Twelfth technical solution is to take several photos of the landing gear mechanism from under the aircraft prior to the landing at high-resolution with a high-speed digital camera, and compare them by a LGRC process to ensure the angle of the landing gear mechanism in relation to the aircraft chassis is the same in all pictures. In the case where LGRC detects inconsistency, a notification is sent to the ATC through the ICM [330], and, a vocal alert is sent over the ATC frequency to the pilot from the AMS [320] along with information displayed on the CPDLC for the flight crew to consider a go-around or a missed approach. In addition, the AMS [320] flashes the runway lights [FIG. 31] of the runway when the LGRC [355] detects a problem, thus allowing the aircraft to visually understand there was no confirmation of a locked landing gear. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0133] Thirteenth technical solution is to automatically send the new departure data to the relevant onboard FMS [130], while displaying the flight crew with the notification of the change made on the CPDLCDU [140]. In addition, the AMS [320] controls the threshold lights of the closed runway and flashes them, allowing all aircraft on final approach to visually understand the runway is closed and the need for a go-
around or a missed approach. For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the specification and example embodiments address these as well as other issues associated with the related art.

[0134] Fourteenth technical solution is to allow Pilots and Airline Operators to set preferred taxiway routes to each of the runways within the airport from different areas of the Airport where the Airline operates. This reduces congestions, waiting for crossings, safety hotspots and direct fuel costs.

[0135] Fifteenth technical solution is to maximize the utilization of takeoff operations from junctions based on aircraft type, weight, historical takeoff information and current wind conditions. For example, a B737 can takeoff from an intersection on most long runways.

[0136] Sixteenth technical solution is to maximize the use of data communication for exchanging information between Pilots and the ATC service, and only use the ATC radio frequency as a backup.

[0137] Seventeenth technical solution is to calculate the landing to takeoff ratio of each runway and to balance future takeoffs by diverting from runways at overcapacity.

[0138] Eighteenth technical solution has two parts, the first part calculates the historical responsiveness of a particular pilot to an ATC command from a historical database, and average taxiing speed and time to cross a junction or a runway, and an expedite directive is only issued to aircrafts historically passing a set average speed and crossing time. In addition, as a second part of the solution, aircrafts receiving an expedite directive are monitored for performance and can be marshalled to increase speed, the heading and break, as covered by another technical solution.

[0139] Nineteenth technical solution is to provide constantly updated information on a dynamic airport map within the cockpit with relevant traffic that may be crossing downfield or affecting the operation, any turbulence from last runway operation that may have affect the aircraft, parallel runway operations that may affect the operation, wind speed, wind direction, initial climb altitude, departures frequency, departure altitude, initial flight heading or navigational aid or GPS guided route, breaking action, bird, FOD and alike.

[0140] Twentieth technical solution is a dynamic airport map within the cockpit, constantly updating information with all relevant aircraft and airport vehicles that are nearby or may affect the aircraft during runway operations. In addition, if selected by a pilot, a synthesized voice constantly provides updates of information relevant to the aircraft, in pilot's selected language.

[0141] Twenty first solution is an automated handoff coordination, whereby all departures are released automatically based on current sector traffic, and, can be managed and administered by a departure controller by managing multiple selectable configurable templates. The departure controller can always manually administer any flight. Templates include optimized departure sequence for departure headings and handoff altitudes for any combination of runways, for any given time span for any day of the week.

[0142] Twenty second solution is a standalone automated system for managing Tower operations, through a single interface, whereby a controller can change the settings, and the system automatically controls the related traffic based on the settings and rules prescribed by the controller.
[0143] Twenty third technical solution is to marshal the maneuvering system, wheel breaks system, and the engine power management system of any aircraft via the communication link and the onboard FMS. Controlling of aircraft is automated when there is a calculated future collision, or, marshalled manually by the commanding tower controller.

[0144] Twenty forth solution displays emergency personnel the best route to take to the pre-calculated final resting position of the aircraft, on a portable device, based on current aircraft location, profile and related physics. In addition, the display includes information related to the aircraft type, number of people onboard, and the calculated or last reported amount of fuel.

[0145] Twenty fifth solution calculates the possibility of a runway overshoot depending on altitude, remaining runway length from current position, runway breaking action, approach profile and aircraft physics, to provides through a cockpit device an audible notification for an possible overshoot, with a visual notification, so the pilot can make a final decision if to go-around or land.

[0146] Twenty sixth solution is providing a display in a cockpit device, displaying updated notifications to airman, as well as messages that have been administered by airport operations control, or commanding controller. In Addition, if a notification or message is related to an area or an object, it is highlighted on a dynamic airport map.

[0147] Twenty seventh solution is a menu display of selectable and available predefined routes, or optional progressive taxi routes, including each route's estimated times to reach the destination. Each selection of an item displays the route on the dynamic map, including current traffic, and by moving the finger on the device over the displayed route path, the pilot is shown the anticipated traffic at any given future point in time in relation to the position within the path.

[0148] Twenty eighth solution displays possible FOD as given by external FOD system, as well the ability for a pilot to report an FOD. A pilot reports FOD simply by selecting the position of the FOD on the map and selecting the FOD displayed menu options. The process is similar for reporting birds and breaking action.

[0149] Twenty ninth solution communicates with other external applications for all airport layout and airside related operations using AIXM to comply with EUROCONTROL and FAA mandates. When a parameter of field is not yet supported by AIXM, it is exported as an extended or user-defined class or object or extended data or metadata.

[0150] Thirtyeth technical solution is a constant process of calculating taxi routes for all current and future aircraft movements, based on current and future traffic positions of aircrafts based on destination and routes, where result of calculations compile a list of complete routes including their paths and time to destination from any current position for each aircraft, as well as proposed progressive taxi route for each aircraft, the list is then stored for future menu options on a per-aircraft basis. In addition, the calculations account for aircraft weight type, restricted areas and routes and alike.

[0151] Thirty first technical solution is to automatically marshal the breaks systems to the aircraft via the communication link and the onboard FMS to control the wheel lock mechanism, or similar device. The breaks are marshalled, or by the commanding controller.
Thirty second technical solution is a device with an airport dynamic map, where full ATC commands services are seen and heard in pilot's preferred language, all related operational information, notifications and options are provided for each phase of the operation. The display is constantly updated with fresh information, including nearby traffic, and conditions affecting the transition of the aircraft from one operation to another.

Thirty third technical solution displays the pilot a satellite image of the airport to easily understand the current location in relation to airport buildings and alike, which are unavailable in most airport diagrams. In addition, distances to the next junction are always updated, and, when nearing a junction to hold short or make a turn, a graphical alert and synthesized voice tell the pilot which way to turn, or heading, as well as any special restrictions and rules for next operation, such as speed and alike, nearby traffic is always shown, with heading, operation type and other options.

Thirty forth technical solution is to externally mount a camera on terminal building overlooking the surface markings near a gate sleeve, and the gate sleeves, mounted high on the terminal in relation to the surface area and gate sleeve, takes pictures at a specified rate, processes by the system, sending pictures and displays the pictures to the pilot as a visual representation to make taxi maneuvering decisions during gate taxi operations such as pushback and alike.

Thirty fifth technical solution is the marshalling of several aircraft takeover, defined by the tower commanding control and authorized by a secondary controller from another facility, is automatically executed to send multiple flight paths to a group of selected aircrafts.

Thirty sixth technical solution is a handheld unit for airport airside personnel or any vehicle moving within the airport, having the same situational awareness and taxi route-selection functionality as a pilot. In addition, any authorized airport personnel or operator within a moving vehicle within the airport, can request a closure of any airside area for maintenance.

Thirty seventh technical solution is to provide pilots with a count-down timer of anticipated time to next command or operation. This greatly increases pilot alertness, and readiness to respond in good time.

Thirty eighth technical solution is to flash the airfield lights based on the direction and exit, or junction an aircraft should take. This ensures pilots do not take wrong paths at junctions or miss their exit.

Thirty ninth technical solution is to record all avionics data and cockpit sounds, and send them for storage for later replay. This also eliminates the need to look for a black-box in case of a crash.

FIG. 1 is a perspective view of the hardware, computers and devices used by the system, including an aircraft [100] in communication with the Server [300]. The aircraft [100] includes a FANS communications System [120] and a Controller Pilot Data Link Communications (CPDLC) [110]. FANS [120] and the FMS [130] both send and receive messages to and from the Server [300] via WCL [600]. The FANS [120] relays Control Messages between the Server [300] and the FMS [130] and/or autopilot [150]. The CPDLC [110] relays Control Messages between the Server [300] and the CPDLCU [140] to interact with a Pilot. The Interactive Controller Module ICM [330] is connected to the Server [300] and allows an ATC to interact and manage AMS [320] operations within the AAATCS. Landing Gear Reporting Cameras (LGRC) [355] are connected to the Server [300] and send images to the AMS [320] to confirm the landing gear is locked.
Emergency Dispatch Module (EDM) [331] notifies emergency personnel in the event of an emergency operation or when AMS [320] detected the landing gear is not locked. Radar [351] and Global Positioning System (GPS) [352] are connected to the Server [300] and provide the AMS [320] updated aircraft location and altitude for within or near the Airport. Aircraft Reporting Sensors (APRS) [353] are connected to the Server [300] and send a signal to the AMS [320] when an aircraft is in range. Movement Detection Cameras (MDC) [354] are connected to the Server [300] and provide the AMS [320] with images of taxiways and junctions for identifying traffic congestions or hotspots. AMS[320] is connected to the AFL [10] for flashing applicable lights to each aircraft for its own operation.

[0161] FIG. 2 is a diagram that further illustrates the data flow between the Server [300] and each of the computers and systems [110,120,130, 140 and 150] aboard the aircraft [100]. The AMS [320] processes system Control Messages and sends them to all other equipment through the server [300]. The ICM [330] allows the ATC to send and receive Control Messages to and from the AMS [320] via the Server [300]. The EDM [331] receives Control Messages from the AMS [320] via the Server [300]. The CPDLCDU [140] permits the pilot to receive and send Control Messages to and from the AMS [320] via the Server [300]. GBCE [310] and FANS [120], for example, the AMS [320] sends a "Landing clearance" Control Message [FIG. 13] to the aircraft [100] and the CPDLCDU [140] will display the related data [FIG. 39]. The Autopilot [150] sends and receives messages to and from the Server [300] via FANS [120] and/or FMS [130], for example, the Server [300] sends a Control Message to the FANS [120] and/or FMS [130] to turn on the autopilot [150] and lock access to it if the aircraft [100] deviates from its course or when the aircraft [100] is squawking any type of distress code (7500 for example). The FMS [130] sends and receives Control Messages to and from the Server [300] via FANS [120]. For example, the Server [300] sends a Control Message to the FMS [130] with rerouting instructions to execute in the case of a Missed Approach or a hijack.

[0162] FIG. 3a illustrates a flow diagram of the processes in a method within the AMS [320] involved in sending a Control Message (CM) to an aircraft for FMS[140], FANS [120] or CPDLCU [140]. The process is used for sending equipment onboard an aircraft [100] a command for execution or, to communicate with the flight crew via the CPDLCDU [140]. 3002 processes the incoming request to send a CM, including the message type and related data [FIG. 5] to be sent with the CM. 3003 processes the data to be included within the CM and 3004 formats the CM data for use at the destination (FANS [120] and/or FMS [130] and/or CPDLCDU [140] and/or autopilot [150]). Once a CM is ready to send, 3005 encrypts the CM for safe transmission and, 3006 transmits the CM to the equipment aboard the aircraft [100] via WCL [600] through GBCE [350] as shown in FIG. 4. To ensure the CM was transmitted successfully in 3006, once the destination equipment (FANS [120] and/or FMS [130] and/or CPDLCDU [140]) onboard the aircraft [100] receives the CM, a CM is generated by the destination equipment (FANS [120] or FMS [130] or CPDLCDU [140]), and a response code is sent back [FIG. 6] to 3007. If the received CM in 3007 was unsuccessful, the message is encrypted again in 3005 and retransmitted in 3006 until the CM is received and a confirmation is returned to 3007. Once the CM was sent successfully to the aircraft [100], the AMS [320] awaits a response from the aircraft [100]. Depending on the type of CM sent by 3006, when the sent CM type is for the flight crew...
(3009), the CPDLC [110] deciphers the CM and display CM content on the CPDLCDU [140] (3012). A code for success or fail is returned by 3013 to the AMS [320] via a CM in 3014 for possible further processing. A tone notification is generated by 3016 if the sent CM requires one (3015). When the sent CM was for the FANS [120], it is deciphered by the FANS [120], and processed. When the sent CM type was for the FMS [130], it is deciphered by the FMS [130] and processed. When the sent CM was for the autopilot [150], it is deciphered by the FMS [130] and sent to the autopilot [150] for processing. When a sent CM is directed at the FANS [120] or FMS [130] or autopilot [150], a code for success or fail is returned by 3011 to the AMS [320] via a CM in 3014 for possible further processing and a tone notification is generated by 3016 if the sent CM requires one (3015). For example, the process is called by process 2107 [FIG. 21] to send a runway crossing CM. Process 3002 looks for the code associated with the "cross runway" and outputs "1002". 3003 processes the runway and junction data required for the "1002" CM. Process 3004 formats the CM and produces an output of: "1002;140;24L;A1", 1002 is the CM code, 140 is for the DPDLCDU, and, 24L; is the runway and A1 is the junction on runway24L. 3005 encrypts the CM and outputs data in an unreadable form to humans, such as "BN4Q2W62YGF47NIQ3W3F" (as an example). 3006 transmits the said encrypted CM by 3005.

3007 receives the code 2101 from the FANS [120] as a confirmation the CM was received. The FANS [120] decrypts the encrypted CM in 3007, and sends it to the CPDLC [110] in 3009 for display by the CPDLCDU [140] in 3012. The CPDLCDU [140] display was successful in 3013, 3015 processes the CM code to confirm a tone notification is needed. 3016 sounds a notification tone. 3014 returns a success code to the AMS [320] by 3017 after the display on the CPDLCDU [140] in 3012 and tone notification in 3016 are complete, and the process of sending and confirming the CM transmission is complete.

[0163] Fig. 3b illustrates a flow diagram of the processes in a method within the AMS [320] involved in sending a Control Message (CM) to an aircraft for the DAMS[161], where the process is similar, however, the infrastructure used, as shown in Fig. where Air/ground communication using the CCS [160] is used to communicate between the server [300] and DAMS[161] aboard the aircraft. In addition, as seen in FIG. 2., DAMS [161] interfaces and is able to exchange control messages with onboard avionics such as the FMS and FANS [120], and alike.

[0164] FIG. 4 illustrates a block diagram of the data communication to further illustrate FIG. 3a in methods involved in sending a Control Message (CM) between the AMS [320] and the various onboard aircraft equipment [110,120,130,140,150]. All ATC commands are processed as a CM within AMS [320], and are sent to an aircraft [100] FANS [120] or CPDLC [110] for the CPDLCDU [140] via the server [300]. The data flow between the server [300] and an aircraft [100] is through the GBCE [310] via WCL [600] or AGC [610]. For example, when a runway crossing CM is processed [FIG. 21], a CM is generated [FIG. 3] and the CM is sent from the server [300] to the CPDLCDU [140] via the GBCE [310], transmitted to the aircraft [100] via the WCL [600]. Once the CM is transmitted to the aircraft, it is received by the equipment based on the WCL protocol. In the case of a runway crossing CM, the CPDLC [110] receives the CM and sends it to the CPDLCDU [140] for displaying the takeoff clearance information. The output of the CM in process 3004
prior to the encryption would be: "1002;140;24L;A1", 1002 is the CM code, 140 is for the DPDLCDU, and, 24L; is the runway and A1 is the junction on runway24L.

[0165] FIG. 5 lists an example of Control Messages (CM) sent to the aircraft [100] by the AMS [320]. Each CM includes a reference code used in decoding a CM aboard the aircraft [100]. The list also illustrates the destination of each message sent by the AMS [320] and the data included within the message processed by processes 3003 and 3004 [FIG. 3]. The format of the CM message is:

\[
\text{Code;Destination;data1;data2;data3..dataN.}
\]

For example, code 1001 is for the CPDLCDU [140] aboard the aircraft [100] and is an ATC directive to hold short of a particular runway junction to be displayed on the CPDLCDU [140] as shown in FIG. 34. The CM output of process 3004 [FIG. 3] is: 1001;140;24L;A1. 1001 is the code, 140 is the code for the CPDLCDU, 24L;A1 is the junction of runway 24L at A1. Each CM includes a reference code used by the AMS [320] CM from the aircraft [100]. The list also illustrates the destination of each message sent by the AMS [320] and the data included within the message processed by [0166] FIG. 6 lists an example of incoming Control Messages (CM) sent to the AMS [320] from any onboard aircraft equipment [110,120,130,140]. The list also illustrates the source of each message sent to the AMS [320] for processing. For example, After the AMS [320] sends a code 1003 [FIG. 5] to "lineup and wait" to the CPDCLDU [140], the Pilot will confirm the ATC directive by selecting "Lining up" [FIG. 35] and the CPDCLDU [140] will return code 1901.

[0167] FIG. 7 lists an example of supported ATC commands processed by the AMS [320] as voice commands over the ATC radio frequency. For example, when a takeoff clearance is issued in process 1207 [FIG. 12] by the AMS [320] to the Pilot of flight AC4554 over the CPDLCDU [140] to takeoff [FIG. 36] from runway 24L at Alpha junction with departure RNAV SID LOREN. A voice command is generated by process 1208 over the ATC frequency saying"AC4554, Cleared for takeoff runway 24L AT ALPHA, RNAV LOREN".

[0168] FIG. 8 illustrates an example of locations for the various Aircraft Position Reporting Devices (APRD) [350], in relation to a runway and taxiway, used by the AMS [320] for updating the Aircraft Locations Database [1010]. The use of a sensor within the illustration may refer to an aircraft [100] location reported by a satellite or a radar device as oppose to a physical sensor. The APRD [350] includes: Aircraft Position Reporting Sensors (APRS) [353]; Movement Detection Cameras (MDC) [354]; Landing Gear Reporting Cameras (LGRC) [355]. APRS [353] locations are at the start of the runway, the touchdown, the lineup area if different from the touchdown area; and, on any exit or crossing or ramp from either direction on either side. In addition to the above, an APRS [353] is placed every 250 feet along the runway starting from the runway pavement, regardless of the marking. The APRS [353] at the end of the lineup position sends a signal to the AMS [320] every time the lineup area has been triggered by either a landing or departing aircraft [100], this signals the AMS [320] the next takeoff can line up on the runway. Additional APRS [353] at taxiway junctions and runway exits signal AMS [320] when an aircraft exits the runway. The additional APRS [353] placed along the runway every 250 feet signal the AMS [320] of the current location on the runway for calculating breaking speeds and runway exits while an aircraft is landing or aborting a takeoff [FIG. 51].
APRS [353] are also placed at all taxiway junctions and every 100 feet along each taxiway from the start of any taxiway pavement or junction, regardless of the markings. APRS [353] at taxiway junctions send a signal to the AMS [320] every time an aircraft passes its range, allowing AMS [320] to determine if an aircraft completed crossing a junction [FIG. 54] and directing the next aircraft [100] to cross the junction. Additional APRS [353] placed along the taxiway every 100 feet to signal the AMS [320] of the current location of an aircraft, allowing AMS [320] to calculate aircraft progress on a taxiway [FIG. 52], and predicting the taxiway congestions level [FIG. 23].

MDC [354] is a physical digital camera capturing images and is placed at every taxiway junction, providing images to the AMS [320] for calculating junction congestions and hotspots [FIG. 55] along with the APRS [353] at taxiway junctions. The LGRC [355] is a physical high-speed digital camera capturing images of the landing gear of a landing aircraft. Each image is sent to the AMS [320] for processing to confirm the landing gear is locked [FIG. 56]. When the landing gear is not confirmed to be locked, the AMS communicate a go-around command [FIG. 16] to an aircraft [100] and/or an alert notification through the ICM [330] to a standby ATC to reconfirm if the landing gear is locked.

FIG. 9 illustrates an example for a typical Airport topology, with Server [300] connectivity with ICM [330], EDM [331] and SAMM [339]. Typically, an ICM [330] is at every ATC position, including: departure ATC; arrivals ATC; and Ground ATC. There is no physical limit to the number of ICM [330] stations aside network restrictions such as IP addressing and alike. An EDM [331] is typically placed at every Emergency unit, including: Fire station; ambulance post or station; security post or station; and Police post or station. There is no physical limit to the number of EDM [331] stations aside network restrictions such as IP addressing and alike. A SAMM [339] is typically placed at every airline operations facility. There is no physical limit to the overall number of SAMM [339] stations not the number of SAMM [339] stations per airline facility, aside network restrictions such as IP addressing and alike.

FIG. 10 illustrates the relationships between the various database categories used by AMS [320]. The databases include: Airport layout [1001]; Airport departures [1002]; Airport arrivals [1003]; Airline gates [1004]; Preferred taxiway routes [1005]; Aircraft locations [1010]; Runway conditions [1011]; and Taxiway conditions [1012]. To increase the clarity of the invention, each data category within the system is shown as a separate database. In practice, the data may reside in a single database or split into several databases in any combination. Airport layout database [1001] stores the Airport static data for locations and procedures, including: names of runways, taxiways and junctions; ATC frequencies, zones, perimeters and handoff points; preferred runways, runway RNAV SID, and missed approach procedures for each runway; and taxiway routes; known congestion areas and hotspots. The data is entered during the Airport setup process, but is easily managed by authorized personnel through the ICM [330]. Airport departures database [1002] stores upcoming and current departure flights, from one hour prior to the departure through thirty minutes after the aircraft was handed-off to depart ATC. The scheduling data is automatically updated from several sources, including: ICM [330]; SAMM [339]; the Airport scheduling system; IATA and/or ICAO systems; and, depending on the geographic location, from the National or Continental Flight Grid. The main reason for
storing data one hour prior to scheduled departure is the need for the system to process anticipated runway use, including the prediction processing runway capacity balancing and takeoff to landing ratios [FIG. 58]; predicting taxiway congestions [FIG. 23]; and avoiding the taxiway congestions and hotspots [FIG. 34]. The main reason for retaining data for aircrafts thirty minutes after handoff to departure ATC is the possibility of a non-scheduled landing when a departing aircraft has an emergency. Airport arrivals database [1003] stores upcoming and current arriving flights, from thirty minutes prior to scheduled touchdown, until the flight is closed. The scheduling data is automatically updated from several sources, including: ICM [330]; SAMM [339]; and the Airport scheduling system. The main reason for storing data thirty minutes prior to scheduled touchdown is the need for the system to process anticipated runway use, including the prediction processing of runway capacity balancing and takeoff to landing ratios [FIG. 58]; predicting taxiway congestions [FIG. 23]; and avoiding the taxiway congestions and hotspots [FIG. 24] on the way from the runway to the gate. Airline gates database [1004] stores common relationships between gates and airline operators to assist the AMS [320] in processing routing and predicting congestion areas within the Airport. The Preferred taxiway database [1005] stores historical and current data for every taxiway combination at different hours, congestion levels and weekdays, AMS [320] uses the data to calculate congestions and hotspots [FIG. 55], as well as allow pilots to select from a list of routes [FIG. 44]. Runway conditions database [1011] stores updated information for each runway at the Airport including: runway conditions; latest breaking action reported by each aircraft type; relevant turbulence information from current or previous runway operation; preferred RNAV SIDs; current wind direction and speed; areas of debris on the runway; runway status; ILS status; current ATC frequencies; and, locations of bird alerts. The information from the runway conditions database is typically used within MS [320] methods and processes to provide Pilots with current information for the runway operation. The Taxiway conditions database [1012] is typically used for storing current status of each taxiway, current congestion levels and future expected traffic, and used by processes for determining best routing to and from runways.

[0173] FIG. 11 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a "lineup and wait" ATC command to an aircraft. 1102 receives current data from the aircraft locations database [1010] on any aircraft currently on the runway or any aircraft that will be landing on the runway shortly. 1103 further checks if the aircraft has passed the lineup area where the next aircraft to takeoff will be. If the aircraft has not passed the lineup position in 1103, it means there is a landing operation taking place and need to wait 1104, and recheck again for aircraft positions 1102. As long as the runway is either clear or a landing aircraft has passed the lineup area, 1105 receives from the aircraft locations database [1010] the closest aircraft to the runway waiting for a takeoff operation. 1106 is processed as a "line-up and wait" Control Message through process 3001 [FIG. 3] and, 1107 outputs a "line-up and wait" voice command over the ATC frequency directed at the flight crew aboard the aircraft. The above example supports "line-up and wait" from any runway junction, for example, "line-up and wait runway 24L at ALPHA". In addition, the process supports the "expedite" directive within the control message and voice commands.
FIG. 12 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a takeoff clearance ATC command to an aircraft. 1202 receives current data from the aircraft locations database [1010] on any aircraft currently on the runway. 1203 checks if there is any aircraft received by the 1202 process. If there is an aircraft on the runway, there is a need to wait 1204, and recheck again for aircraft positions 1202. As long as the runway is clear 1204 receives from the database [1011] the latest runway conditions applicable for the takeoff operation including: wind direction and speed; and possible alert on birds. 1206 receives aircraft departure data including the RNV SID or departure heading and/or initial climb altitude, and, contact information for departure ATC including frequency and altitude for switching to the departure ATC frequency. 1206 includes turbulence advisory from previous runway operation when relevant, 1207 creates a takeoff clearance Control Message processed by 3001 [FIG. 3], and 1208 outputs the takeoff clearance ATC directive over the ATC radio frequency. The process supports takeoff clearance from any runway junction, for example, "cleared for takeoff runway 24L at ALPHA". In addition, the process supports the "immediate" and "expedite" directives within the control message and voice commands.

FIG. 13 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a landing clearance ATC command to an aircraft. 1302 receives current data from the aircraft locations database [1010] on any aircraft currently on the runway. 1303 checks if there is any aircraft received by the 1202 process. If there is an aircraft on the runway, there is a need to issue go around Control Message 1314 using process 1601 [FIG. 16]. If there is no aircraft on the runway, 1304 gets the runway conditions applicable for the landing operation including: wind direction and speed; and possible alert on birds. 1309 gets the assigned gate, associated runway exit and ATC Ground frequency. 1306 adds turbulence advisory information if applicable and 1308 outputs the landing clearance ATC directive over the ATC radio frequency.

FIG. 14 illustrates a flow diagram of the processes in a method within the AMS [320] involved in updating CPDLC DU [140] while an aircraft is rolling during a takeoff operation with the possibility the takeoff will be aborted. After the flight crew aboard an aircraft [100] confirms the takeoff clearance 1402 by manually actuating the button [141] associated with the "rolling" function on the CPDLC DU [140]. 1403 receives all possible runway exits from the Airport Layout Database [1001] in case the takeoff is aborted and needs to exit the runway. 1404 receives the latest aircraft location from the aircraft location database [1010], 1405 checks if the aircraft is still rolling or airborne. If the aircraft is no longer on the runway, the process ends. Once 1405 determined the aircraft is still on the runway, 1406 receives from the airport conditions database [1011] the latest runway conditions applicable for the takeoff operation, including turbulence from previous runway operation, wind direction and speed and possible alert on birds. 1407 calculates the possible exits in case the takeoff is aborted. 1408 checks if there are any changes since the last message sent to the CPDLC DU [140], if there are no changes since the last update sent to the CPDLC DU [140] the process waits for 5 seconds 1412 and restarts by receiving the latest Aircraft Position 1504. If there were changes since the last update sent to the CPDLC DU [140], 1409 prepares a new CPDLC DU [140] message containing any changes in the runway conditions from 1406 and, with the exit information from 1407 in case the takeoff is aborted. 1410 sends the Control Message to CPDLC DU [140] for display, 1411 displays the updated
information on the CPDLCDU [140] for the flight crew. The process waits for 5 seconds 1412, and restarts by receiving the latest Aircraft Position 1404. The process continues for as long as the aircraft is on the runway unless the takeoff was aborted or the aircraft is airborne.

[0177] FIG. 15 illustrates a flow diagram of the processes in a method within the AMS [320] involved in updating CPDLCDU [140] while an aircraft is breaking during a landing operation. Once the landing aircraft [100] is over the runway area, regardless if a touchdown occurred, 1502 gets the available exits for the runway in use. 1503 is constantly updated with the latest aircraft [100] location on the runway from the Aircraft Location Database [1010]. 1504 determines if the aircraft has landed and has started breaking. 1505 stops flashing the exit AFL[10] lights [FIG. 30] if 1504 has determined that the aircraft is no longer on the runway and the process is terminated. 1507 gets the latest runway conditions from the Runway Conditions Database [1011] and 1508 receives the updated list of available runway exists from process 5101 [FIG. 51]. 1510 compares the latest data with the last sent Control Message stored in 1409. If there is no change from last sent Control Message in 1510,1514 waits and restarts the process from 1503 for as long as the aircraft is landing, breaking or is still on the runway. If the latest information is different than the last sent Control Message [1510] stored in 1409, 1511 stores the latest Control Message in 1509 for the next time 1510 is executed. Once 1511 stores the latest Control Message in 1509, 1512 uses process 3001 [FIG. 3] to display the latest information to the flight crew [FIG. 40]. The exit lights processed by 1508 will flash for as long as the aircraft [100] has not passed the exit or cleared the runway. As 1508 output changes an exit, the prior exit AFL[10] lights stop flashing. 1514 waits and restarts the process from 1503 for as long as the aircraft is landing, breaking or is still on the runway.

[0178] FIG. 16 illustrates a flow diagram of the processes in a method within the AMS [320] involved with managing a Go-Around or Missed Approach. Once a Pilot requests a Go-Around or a Missed Approach, 1602 gets information related to missed approach and go-around from the Airport Layout Database [1001]. 1603 decides on a missed approach or go-around based on the incoming request. For Go-Around, 1604 sends a confirmation through process 3001 [FIG. 3] to update the CPDLCDU [140] with relevant information related to the Go-Around [FIG. 42]. 1605 outputs a "Go-Around" voice command over the ATC frequency directed at the flight crew aboard the aircraft. In addition, 1606 notifies the departure ATC of the go-around through the ICM [330] display and 1607 sounds a tone related to a go-around over the ICM [330] to ensure the departure ATC is notified. For a Missed Approach, 1610 sends a confirmation through process 3001 [FIG. 3] to update the CPDLCDU [140] with relevant information related to the Missed Approach [FIG. 41], 1611 outputs a "Missed Approach" voice command over the ATC frequency directed at the flight crew aboard the aircraft. In addition, 1612 notifies the departure ATC of the Missed Approach through the ICM [330] display and 1613 sounds the tone related to a Missed Approach over the ICM [330] to ensure the departure ATC is notified. In both Go-Around and Missed Approach, 1608 flashes the runway lights [FIG. 31] to notify the pilot not to land.

[0179] FIG. 17 illustrates a flow diagram of the processes in a method within the AMS [320] involved with accepting an aircraft handoff from Approach ATC. The ATC selects the aircraft to handoff via the ICM [330]
1702, the ICM [330] sends the AMS [320] a handoff request for the aircraft 1703. 1704 receives the latest location and speed from the aircraft from the location database [1010] for the aircraft being handed off. 1705 calculates if there is enough time to handle the aircraft after the handoff. 1706 decides to accept the handoff based on the calculations in 1705. If 1706 decides to accept the handoff, 1707 sends the ICM [330] a message for accepting the handoff operation. Once the handoff is accepted, 1708 displays the handoff was accepted on the ICM [330] and sounds an audio tone associated with accepting a handoff 1709. If 1706 decides there is not enough time to handle the aircraft, 1711 further checks ATC allows automated go-around if a handoff is refused. If ATC allows automated go-around and, if a handoff is refused, 1707 sends the ICM [330] a message for accepting the handoff operation, 1708 displays the handoff was accepted on the ICM [330] and sounds an audio tone associated with accepting a handoff 1709. 1715 will issue a go-around directive via process 1601 [FIG. 16] when 1711 checks if ATC allows for automated go-around on refused handoffs. If 1711 outputs false, 1712 sends the ICM [330] a message for refusing the handoff operation. Once the handoff is refused, 1713 displays the handoff was refused on the ICM [330] and sounds an audio tone associated with refusing a handoff 1714.

[F0180] FIG. 18 illustrates a flow diagram of the processes in a method within the AMS [320] involved with an aircraft handoff operation to Departure. Once an aircraft is airborne, 1802 receives the latest Departures handoff altitude and frequency associated with the runway. 1803 receives the altitude of the aircraft, and 1804 checks for the aircraft altitude to be above the handoff altitude from 1802. As long as the aircraft has not reached the handoff altitude, the aircraft altitude is checked every 5 seconds 1805. Once the aircraft reached the handoff altitude, AMS [320] sends ICM [330] a handoff request message 1806, to display to the ATC for acceptance 1807 and sound a tone associated with a handoff request 1708. Once the ATC accepts the aircraft handoff request from the ICM [330] in 1809 over the ICM [330], the ICM [330] sends AMS [320] a message of handoff acceptance 1811, and sounds a tone to the ATC over the ICM [330] associated with a handoff acceptance 1813. Until ATC accepts the handoff in 1809, 1810 waits and redispays the handoff request 1807 and sounds the handoff request tone in 1808 every 5 seconds.

[F0181] FIG. 19 illustrates a flow diagram of the processes in a method within the AMS [320] involved with automatically accepting an aircraft handoff from Ground ATC. Once ATC selected the aircraft for handoff [100] through the ICM [330] 1902, the ICM [330] sends a ground handoff request to AMS [320] 1903, 1904 accepts the handoff and adds to the overall workload of the AMS [320]. The ICM [330] displays the handoff acceptance to the ATC 1705 and sounds a tone to the ATC over the ICM [330] associated with a handoff acceptance 1706. Depending on regulations, it is typical for Pilots switch to Ground ATC frequencies and the handoff between Controllers is not required.

[F0182] FIG. 20 illustrates a flow diagram of the processes in a method within the AMS [320] involved with an aircraft handoff operation to Ground ATC. Once an aircraft has crossed the runway or is exiting the runway from a landing, 2002 receives the ATC frequency associated with the runway. 2003 receives the aircraft position, and 2004 checks for the location of the aircraft in relation to the handoff location from 2002. As long as the aircraft has not reached the handoff location, the aircraft location is rechecked every 5 seconds 2005.
Once the aircraft reached the handoff location, AMS [320] sends ICM [330] a handoff request message 2006, to display to the ATC for acceptance 2007 and sound a tone associated with a handoff request 2008. Once the ATC accepts the aircraft handoff request from the ICM [330] in 2009 over the ICM [330], the ICM [330] sends AMS [320] a message of handoff acceptance 2011, and sounds a tone to the ATC over the ICM [330] associated with a handoff acceptance 2013. Until ATC accepts the handoff in 2009, 2010 waits and redispays the handoff request 2007 and sounds the handoff request tone in 2008 every 5 seconds. Depending on regulations, it is typical for Pilots to switch from Ground frequency and the handoff between Controllers is not required.

[0183] FIG. 21 illustrates a flow diagram of the processes in a method within the AMS [320] involved in Timing runway crossings during landing operations. 2102 gets the exits and taxiways related to the runway from the Airport Layout Database [1001]. 2103 gets current runway operation and the next scheduled landing from the Aircraft Location Database [1010]. 2104 checks if there is any aircraft rolling or is during a landing and did not passed the crossing junction. As long as 2104 outputs false, 2105 waits and retries to check in 2103 of any aircraft operations. Once a takeoff roll or a landing passed the crossing junction, 2106 will further check is there is sufficient time to complete the crossing operation prior to the next operation. If there isn't enough time, 2105 will wait and locations of other aircraft operations will be rechecked again in 2103. Once 2106 calculates there is enough time to cross the runway, 2107 uses process 3001 [FIG. 3] to display the Pilot the ATC command to cross the Runway. In addition, 2108 outputs a "cross runway" voice command over the ATC frequency directed at the flight crew aboard the aircraft.

[0184] FIG. 22 illustrates a flow diagram of the processes in a method within the AMS [320] involved in simultaneously managing multiple runway operations. 2202 retrieves active runways in use from the Airport Layout Database [1001]. 2203 extracts all taxiways for each of the active runways from the Airport Layout Database [1001]. 2204 retrieves the next 10 scheduled landings and next 2 takeoffs for each of the active runways from the Aircraft Locations Database [1010]. 2206 retrieves the updated runway conditions for each of the active runways from the Runway Conditions Database [1011]. Once all the data is pulled, 2207 calculates the time when an aircraft on each of the runways used for takeoffs will be airborne. After 2007 calculates airborne time for each of the active runways, 2208 checks for the next takeoff scheduled for each of the runways. As long as there are no scheduled takeoffs left on any of the active runways, the process is complete 2209. For as long as there are still scheduled takeoffs on any of the runways, 2210 checks if there is enough time to execute the takeoff operation on each runway. If there is no time on all of the runways for a takeoff the process is terminated 2209 and 2202 will be executed again after the next landing on any of the runways. As long as there is enough time for a takeoff on at least one runway, 2211 will request release from departure ATC using process 5301 [FIG. 53] for each takeoff. For every release approved by departure ATC 2212, during parallel takeoff operations without an RNAV SID, 2213 applies the 15 degree rule on the heading of the takeoff. Each of the takeoffs are handled by process 1201 [FIG. 12]. The processes is repeated for as long as 2202 calculates there is enough time for at least one takeoff.
[0185] FIG. 23 illustrates a flow diagram of the processes in a method within the AMS [320] involved with predicting taxiway congestions and hotspots. 2302 extracts all runways, taxiways, junctions and routes from the Airport Layout Database [1001]. 2303 retrieves the active runways in use. 2304 retrieves the scheduled departures with their assigned routes to the runway from the Aircraft Location Database [1010]. 2305 retrieves the scheduled arrivals with their assigned routes after landing from the Aircraft Location Database [1010]. 2306 processes all the assigned routes of all the departures and arrivals retrieved by 2304 and 2305. 2307 processes the current locations of all aircrafts moving on taxiways and runways. Once all the data is readily available for processing, 2309 calculates the future anticipated position for each aircraft for every minute until the flight has either departed or closed. 2310 readjusts the location of each aircraft positions based on the number of aircrafts at each junction at the each point in time. The location data is stored in 2308 for each aircraft for every minute. 2311 ranks each taxiway and junction based on the number of aircrafts in the area and 2312 stores the data for every minute for every taxiway and junction to be used by processes related to calculating aircraft progress on a taxiway [FIG. 52], calculating junction congestions [FIG. 55], congestion avoidance [FIG. 24] and allowing a Pilot to select from preferred list of routes to and from a runway [FIG. 44]. After 2312 stores the data, 2314 forces process 2309 to be executed sixty times resulting in future congestion data for sixty minutes available to the above processes.

[0186] FIG. 24 illustrates a flow diagram of the processes in a method within the AMS [320] involved in avoiding congested taxiways and hotspot crossings when assigning routing to and from a runway. 2402 extracts all runways, taxiways, junctions from the Airport Layout Database [1001]. 2403 extracts all available routes based on origin and destination endpoints. 2404 retrieves the taxiway and junction congestion data from process 2301 [FIG. 23]. 2405 ranks all origin to destination endpoint routes based on the congestions and hotspots data. 2406 retrieves the preferred routes for each of the airline from the Preferred Taxiway Routes Database [1005]. 2407 processes the preferred airline routes with the ranked routes from 2405 and assigns the best possible route to the aircraft based on airline preference, anticipated congestion levels, expected taxi time and use of fuel. 2409 sends the Pilot a routing selection Control Message through process 3001 [FIG. 3] and the Pilot can accept the route of select another route. If a Pilot selects a different route 2410 through the CPDLCU [140] as shown in FIG. 44, the selected route will be assigned 2411.

[0187] FIG. 25 illustrates a flow diagram of the processes in a method within the AMS [320] to maximize takeoff operations on long runways. 2502 retrieves all scheduled departures and assigned takeoff runway from the Airport Departures Database [1002]. 2503 retrieves all the runway junctions that can be used for safe takeoff operations by the type of aircraft from the Airport Layout Database [1001]. 2504 assigns the new takeoff junction instead of the default start of runway location. 2505 uses process 2401 [FIG. 24] to reassign preferred routing to the runway and 2506 recalculates the estimated time for takeoff. For example: a runway totaling 11,000 feet with a junction 3,000 feet from the lineup position has a junction, leaving 8,000 feet of usable runway pavement. The 8,000 feet provide safe takeoff for a B737 in most conditions. This solution provides optimal use of runway and more spacing between takeoffs followed by a landing operation.
FIG. 26 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a turbulence advisory during landing or takeoff clearance, in accordance with an example embodiment, 2602 gets current runway operation from the Aircraft Locations Database [1010], the process is terminated and if the aircraft type is not classified as "Heavy" in 2603. If 2604 determines the aircraft classification is Heavy", 2605 retrieves the current location of the aircraft. 2606 calculates the distance between the current operation and the next takeoff or landing operation. 2607 determines if the turbulence can affect the next landing of takeoff operation. If 2607 outputs false the process is terminated. If 2607 output is true, 2608 looks if the next operation is a takeoff or a landing. If the next operation is a takeoff, 2609 adds a turbulence warning to the Command Message in process 1207 [FIG. 12] and 2610 adds a turbulence warning to the voice buffer in process 1208 [FIG. 12]. If the next operation is a takeoff, 2611 adds a turbulence warning to the Command Message in process 1207 [FIG. 12] and 2612 adds a turbulence warning to the voice buffer in process 1208 [FIG. 12]. For example, a takeoff with a turbulence warning would include the phrase "caution turbulence for a departing 747" in both the Command Message and within the voice takeoff clearance over the voice ATC.

FIG. 27 illustrates a flow diagram of the processes in a method within the AMS [320] for displaying ATC commands and allowing Pilot confirmation through the CPDLCDU [140]. 2702 displays the Message sent by the Command Message from process 3012 [FIG. 3]. A CPDLC tone notification will sound (3005) every 5 seconds (2704) to remind the flight crew they need to attend to the Message on the CPDLCDU [140] and press one of the illuminated options buttons from the right of the CPDLCDU [140] (1R,2R,3R,4R,5R,6R). Each of the buttons (1R,2R,3R,4R,5R,6R) refer to the corresponding displayed options on the right side of the CPDLCDU [140], only illuminated buttons can be pressed, where illuminated buttons have corresponding option text and non-illuminated do not have corresponding option text. Once the flight crew press one of the illuminated buttons 2703, 2706 processes the corresponding illuminated button and outputs the associated code [FIG. 6]. 2707 returns the code from 2706 associated to the option pressed. For example, after a takeoff clearance Control Message was sent [FIG. 12]. The CPDLCDU [140] shows a screen for the takeoff clearance [FIG. 36]. The flight crew can press the button "1R" for confirming the aircraft is starting with the takeoff, or button "3R" to notify that they are unable to start the takeoff roll, or button "4R" to notify they are aborting the takeoff operation. The Pilot presses the button "1R" to confirm the aircraft is starting the takeoff roll.

FIG. 28 illustrates a flow diagram of the processes in a method within the AMS [320] to automatically recognize and reply to Pilot requests over ATC voice frequency. 2802 sends the incoming voice to an external software package that outputs the equivalent text. 2803 looks within the data (2804) for known words that are within the text. If there are no matches, the process is terminated 2806. Once there is a match between one of the words from the known words in 2804 with the incoming text, 2807 retrieves the request code associated with the matched word. 2808 processes the data related to the code. If the code is a request in 2809, depending on the request type, 2810 retrieves the data from the appropriate database and outputs the data to 2812 converting the text to a voice, once 2812 converts the data to voice, 2813 will sound the voice over the ATC radio frequency. If the code is a confirmation for previous command 2814, 2815 returns the confirmation code.
to the original process that is waiting for the confirmation code. If the code is not a request and is not a
confirmation, 2816 executes the process related to the code. For example, if a Pilot presses the button "2R" in
the lineup and wait on the CPDLCDU [140] as shown in FIG. 35, the return code would trigger the takeoff
clearance in process 1201 [FIG. 12]. Since recognition of Pilot communication of the voice ATC frequency is
an external process (2802), the words associated to the commands are managed by modifying the supported
request types in the data in 2804. The determining factor for adding words or phrases is the uniqueness of the
sound where each word or phrase must be unique to ensure the proper functionality of the external process
called by 2802.

[0191] FIG. 29 lists an example of the recognized Pilot requests and responses over ATC voice frequency
supported by the system. The list includes common terminology and phrases used in Pilot - ATC
communication and can be modified to suite geographical areas and specific regulations. For example, in
some geographical areas, "lineup and wait" is addressed as "position and hold".

[0192] FIG. 30 illustrates the location of the exit flashing AFL[10] light to notify a Pilot where to exit the
runway. The exit flashing AFL[10] lights are located on both sides of every taxiway on every crossing. The
exit flashing AFL[10] lights is a group of 5 lights, where the first light starts at the corner of the runway and
the taxiway. The flashing sequencing is on for two seconds and off for one second. The sequence is repeated
until the aircraft has passed the junction or has exited the taxiway. The exit flashing AFL[10] lights are
typically controlled by processes 1513 [FIG. 15] and 2109 [FIG. 21].

[0193] FIG. 31 illustrates the location of the flashing AFL[10] lights to notify Pilots of a closed runway. The
closed runway flashing AFL[10] lights is a group of lights in a row, located before the start of the paved
runway, the lights are spaced 3 feet from one another and cover the complete width of the runway. The
flashing sequencing is on for one second and off for two seconds. The closed runway flashing AFL[10] lights
are controlled by the Missed Approach and Go-Around process 1608 [FIG. 16].

[0194] FIG. 32 illustrates a flow diagram of the processes in a method within the AMS [320] to dispatch
emergency personnel when the landing gear of an aircraft is not locked prior to the landing. 3202 retrieves the
estimated area the aircraft will touchdown and come to a complete stop from the Aircraft Positions Database
[1010]. 3203 retrieves the emergency units relates to the areas from 3202. 3204 sends a notification to the
EDM [331] to display the relevant aircraft information for emergency personnel 3205. In addition to the
display of the information on the EDM [331] with a notification, 3206 sounds the Emergency Announcement
System (EAS) [340] to the EDM [331]. Processes 3204 through 3206 are executed for each emergency unit
covering the areas from 3203. For example, There are two fire stations responsible for a Runway, one from
the touchdown area to the midfield, and the second from the midfield to the end of the runway. Since the
landing aircraft has been identified by process 5601 [FIG. 56] to have a landing gear that is not locked, Both
fire stations would be dispatched.

[0195] FIG. 33 lists the types of CPDLCDU [140] screens available to the Pilots and flight crews sent from
the AMS [320]. Illustrations of CPDLCDU [140] screens include options for flight crew to select. Typically,
the option buttons are on the right labeled: 1R; 2R; 3R; 4R; 5R and 6R. Also, in most illustrations the 6L
button on the bottom left of the CPDLCU [140] allows the flight crew to return to the previously displayed screen. The buttons 1R, 2R, 3R, 4R, 5R and 6R are used in process 2701 [FIG. 27] to decode the pressed button to the related option code for processing in the AMS [320]. It is important to stress, that DAMS[161] provide the same functionality of all listed CPDLCU [140] screens, codes and control messages.

[0196] FIG. 34a illustrates an example output of the onboard CPDLCU [140] related to a "hold short" ATC directive on a runway prior to a takeoff clearance to a specific aircraft generated in FIG. 57. After a hold short directive is issued by ATC, the left side contains the following information: location of where to hold short; assigned departure heading or RNAV SID; current wind direction and speed; frequency and altitude for contacting departure after airborne. The flight crew can press "1R" to acknowledge the hold short as a read-back confirmation, or "2R" to inform the system that the aircraft is holding short at the designated location [1L].

[0197] FIG. 34b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on CPDLCU [140], and, providing highest safety through pilot situational awareness of locations refreshed surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 34a.

[0198] FIG. 35a illustrates an example output of the onboard CPDLCU [140] related to a "lineup and wait" ATC directive on a runway prior to a takeoff clearance to a specific aircraft as generated in FIG. 11. After a lineup and wait directive is issued by ATC, the left side contains the following information: current wind direction and speed; assigned departure heading or RNAV SID; departure frequency and contact altitude; relevant turbulence information from the last runway operation prior to the takeoff. The flight crew can press the following buttons: "1R" to accept the line-up and wait directive as a read-back confirmation; "2R" to inform the system as being ready for the takeoff roll; "3R" to inform the system of not being ready to line up.

[0199] FIG. 35b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on CPDLCU [140], and, providing highest safety through pilot situational awareness of locations refreshed surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 35a.

[0200] FIG. 36a illustrates an example output of the onboard CPDLCU during the takeoff clearance of an aircraft as generated in FIG. 12. After a takeoff clearance is issued by ATC, the left side contains the following information: current wind direction and speed; relevant turbulence information from the last runway operation prior to the takeoff; assigned departure heading or RNAV SID; the takeoff location on the runway; departure frequency and contact altitude. The flight crew can press the following buttons: "1R" to accept the takeoff clearance as a read-back and inform the system of starting the takeoff roll; "3R" to inform the system of not being ready to start the takeoff roll; 4R to inform the system of aborting the takeoff.

[0201] FIG. 36b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on CPDLCU [140], and, providing highest safety through pilot situational awareness of locations refreshed surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 36a.
FIG. 37a illustrates an example output of the onboard CPDLCDU [140] after the aircraft starts the takeoff roll as generated in FIG. 14. Once the aircraft starts the takeoff roll the Left side contains the following information: updated current wind direction and speed; relevant turbulence information; assigned departure heading or RNAV SID; the takeoff location on the runway; departure frequency and contact altitude. The flight crew can press the following buttons: "1R" to inform the system when airborne; "3R" to inform the system of an emergency; 4R to inform the system of aborting the takeoff.

FIG. 37b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on CPDLCDU [140], and, providing highest safety through pilot situational awareness of locations refreshed surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 37a.

FIG. 38a illustrates an example output of the onboard CPDLCDU [140] after the aircraft is airborne, Once the aircraft is airborne, the left side contains the following information: updated current wind direction and speed; relevant turbulence information; assigned departure heading or RNAV SID; the initial climb altitude; departure frequency and contact altitude. The flight crew can press the following buttons: "1R" to inform the system of switching to departure frequency; "3R" to inform the system of not being ready to start the takeoff roll; 4R to inform the system of an emergency.

FIG. 38b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on CPDLCDU [140], to provide highest possible situational awareness of locations for emergency exits, updated surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 38a.

FIG. 39a illustrates an example output of the onboard CPDLCDU device that shows a generated ATC command and related information for a landing clearance to a specific aircraft generated in FIG. 13. Once an aircraft is issued a landing clearance, the left side contains the following information: updated current wind, direction and speed; relevant turbulence information; runway clearance; runway conditions and latest breaking action reported by same or similar aircraft type; assigned exit and ground frequency to contact after exiting the runway. The flight crew can press the following buttons: "1R" to confirm the landing clearance as a readback; "2R" request a different runway exit or full runway [FIG. 43]; "3R’ select a routing [FIG. 44]; "4R" inform the system of a missed approach; "5R" inform the system of a go-around.

FIG. 39b illustrates an example output of the onboard DAMS[161] with additional information that is unavailable on the CPDLCDU [140], to provide additional functionality and highest possible situational awareness during the same aircraft operation as described in Fig. 39a.

FIG. 40a illustrates an example output of the onboard CPDLCDU [140] device that shows the update sent to the CPDLCDU [140] for a breaking operation of a landing aircraft generated in FIG. 15. The left side contains the following information: assigned exit; ground frequency to contact once cleared the runway. The flight crew can press the following buttons: "1R” to inform the system of clearing the runway; "2R" request a different runway exit or full runway [FIG. 43]; "3R” request routing [FIG. 44]; "4R” report breaking action [FIG. 45]; "5R” report runway conditions [FIG. 46].
FIG. 40b illustrates an example output of the onboard DAMS[16] with additional information that is unavailable on the CPDLCU [140], to provide additional functionality and highest possible situational awareness during the same aircraft operation as described in Fig. 40a.

FIG. 41a illustrates an example output of the onboard CPDLCDU [140] device that shows the information displayed during a generated in FIG. 16. The left side contains the following information: published missed approach type; climb altitude and heading if different from runway heading; direct to a NAVAID name or any published pattern for the missed approach; frequency to contact. The flight crew can press the following buttons: "1R" to inform the system of switching to another frequency; "3R" to inform the system of being unable to execute the missed approach; "4R" to declare an emergency and land.

FIG. 41b illustrates an example output of the onboard DAMS[16] with additional information that is unavailable on the CPDLCU [140], to provide additional functionality and highest possible situational awareness during the same aircraft operation as described in Fig. 41a.

FIG. 42a illustrates an example output of the onboard CPDLCDU [140] device that shows the information displayed for a Go-Around operation generated in FIG. 16. The left side contains the following information: go-around type; climb altitude; heading if different from runway heading; frequency to contact. The flight crew can press the following buttons: "1R" to inform the system of switching to another frequency; "3R" to inform the system of being unable to execute the missed approach; "4R" to declare an emergency and land.

FIG. 42b illustrates an example output of the onboard DAMS[16] with additional information that is unavailable on the CPDLCU [140], to provide additional functionality and highest possible situational awareness during the same aircraft operation as described in Fig. 42a.

FIG. 43a illustrates an example output of the onboard CPDLCDU [140] device that allows flight crew to request a runway exit from a list of exits generated by FIG. 50. The left side contains the available exits. The flight crew can select any of the buttons corresponding to the exit. "1R" for A full runway, "2R" for ALPHA exit, "3R" for DELTA exit, "2R" for ECHO exit. The right side of the CPDLCDU [140] is when more than 5 exits are available.

FIG. 43b illustrates an example output of the onboard DAMS[16] with additional information that is unavailable on CPDLCU [140], and, providing highest safety through pilot situational awareness of locations refreshed surrounding traffic and additional functionality that are relevant to the operation, and alike, during the same aircraft operation as described in Fig. 43a.

FIG. 44 illustrates an example output of the onboard CPDLCDU [140] device that allows flight crew to select a routing from a list of routes generated by FIG. 24. The left side contains up to 5 routes. Each route includes the estimated time for the complete route as well as the congestion level (low, med, high), route path with taxiways, junctions and runway crossings. The flight crew can select any of the buttons from the left that have corresponding routes. In this example, 1L, 2L and 3L can be pressed as they have corresponding routes. Buttons 4L and 5L do not have corresponding routes and are not usable.
FIG. 45 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report a runway breaking action, handled by FIG. 59. The left side allows flight crew to press one of buttons that correspond to one of the following breaking action types: "IL" very good; "2L" good; "3L" average or fair; "4L" bad; "5L" very bad or NIL.

FIG. 46 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report runway conditions, handled by FIG. 60. The left side allows flight crew to press one of buttons that correspond to one of the following runway conditions: "IL" dry; "2L" wet or water; "3L" icy; "4L" snow cover; "5L" flooded. Some regions have additional runway condition types that can be added on the display, such as oily, slush, sand and mud.

FIG. 47 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report bird activity handled by FIG. 61. All buttons numbered 1 through 5 are used on both sides of the CPDLCDU. Flight crew can select from any of the corresponding locations from one of the following buttons: IL; 2L; 3L; 4L; 5L; IR; 2R; 3R; 4R; and 5R. each of the buttons refer to a location in reference to the runway.

FIG. 48 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report debris on runway handled by FIG. 62. All buttons numbered 1 through 5 are used on both sides of the CPDLCDU. Flight crew can select from any of the corresponding locations from one of the following buttons: IL; 2L; 3L; 4L; 5L; IR; 2R; 3R; 4R; and 5R. each of the buttons refer to a location in reference to the runway.

FIG. 49a illustrates an example of the onboard CPDLCDU [140] menu. The Menu provides common options to set common preferences.

FIG. 49b illustrates a partial example of the onboard DAMS [161] main menu options. The Menu provides common options to set common preferences, as well as reporting as discussed in Figs. 45 through 48.

FIG. 50 illustrates a flow diagram of the processes in a method within the AMS [320] involved with a Pilot runway exit request. 5002 receives the requested exit from the CPDLCDU [140] as shown in FIG. 43. 5003 retrieves the preferred routes for each of the airline from the Preferred Taxiway Routes Database [1005]. 5004 processes the best 3 routes from the airline routes, 5005 assigns the best route of the 3 to the aircraft. 5006 sends the Pilot a routing selection Control Message through process 3001 [FIG. 3] and the Pilot can accept the route or select another route [FIG. 44]. If a Pilot selects a different route 5007 through the CPDLCDU [140] as shown in FIG. 44, selected route is assigned 5008.

FIG. 51 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating breaking speeds and runway exits while an aircraft is landing or aborting a takeoff. 5102 gets the last 5 positions reported and stored in the Aircraft Locations Database [1010]. 5103 calculates the rate of change between the last 5 locations based on the timestamp of each location data. 5104 calculates the stopping location where the aircraft can safely exit the runway. 5105 extracts the next few exits beyond the stop location and 5106 assigns the first exit to the aircraft. 5107 sends the Pilot an exit selection Control Message
through process 3001 [FIG. 3] and the Pilot can accept the route or select a different exit from one of the other exits extracted in 5105. If a Pilot selects a different route through the CPDLCDU [140] as shown in FIG. 44 in 5108, 5109 will assign the exit selected by the Pilot.

[0205] FIG. 43b illustrates an example screen of the onboard DAMS[161] with easier interface for the user for providing additional functionality as described in Fig. 43a.

[0206] FIG. 44 illustrates an example output of the onboard CPDLCDU [140] device that allows flight crew to select a routing from a list of routes generated by FIG. 24. The left side contains up to 5 routes. Each route includes the estimated time for the complete route as well as the congestion level (low, med, high), route path with taxiways, junctions and runway crossings. The flight crew can select any of the buttons from the left that have corresponding 30 routes. In this example, 1L, 2L and 3L can be pressed as they have corresponding routes. Buttons 4L and 5L do not have corresponding routes and are not usable.

[0207] FIG. 45 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report a runway breaking action, handled by FIG. 59. The left side allows flight crew to press one of buttons that correspond to one of the following breaking 35 action types: "1L" very good; "2L" good; "3L" average or fair; "4L" bad; "5L" very bad or NIL.

[0208] FIG. 46 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report runway conditions, handled by FIG. 60. The left side allows flight crew to press one of buttons that correspond to one of the following runway conditions: 40 "1L" dry; "2L" wet or water; "3L" icy; "4L" snow cover; "5L" flooded. Some regions have additional runway condition types that can be added on the display, such as oily, slush, sand and mud.

[0209] FIG. 47 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report bird activity handled by FIG. 61. All buttons numbered 1 45 through 5 are used on both sides of the CPDLCDU are used. Flight crew can select from any of the corresponding locations from one of the following buttons: 1L; 2L; 3L; 4L; 5L; 1R; 2R; 3R; 4R; and 5R. Each of the buttons refer to a location in reference to the runway.

[0210] FIG. 48 illustrates an example output of the onboard CPDLCDU [140] device that allows the flight crew to report debris on runway handled by FIG. 62. All buttons numbered 1 through 5 are used on both sides of the CPDLCDU are used. Flight crew can select from any 5 of the corresponding locations from one of the following buttons: 1L; 2L; 3L; 4L; 5L; 1R; 2R; 3R; 4R; and 5R. Each of the buttons refer to a location in reference to the runway.

[0211] FIG. 49a illustrates an example of the onboard CPDLCDU [140] menu. The Menu provides common options to set common preferences.

[0212] FIG. 49b illustrates an example output of the onboard DAMS [161] that allows the flight crew to report debris on runway, in accordance with an example embodiment.

[0213] FIG. 50 illustrates a flow diagram of the processes in a method within the AMS [320] involved with a Pilot runway exit request. 5002 receives the requested exit from the CPDLCDU [140] as shown in FIG. 43. 5003 retrieves the preferred routes for each of the airline from the Preferred Taxiway Routes Database
[1005]. 5004 processes the best 3 routes from the airline routes, 5005 assigns the best route of the 3 to the aircraft. 5006 sends the Pilot a routing selection Control Message through process 3001 [FIG. 3] and the Pilot can 15 accept the route of select another route [FIG. 44]. If a Pilot selects a different route 5007 through the CPDLCDU [140] as shown in FIG. 44, selected route is assigned 5008.

[0214] FIG. 51 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating breaking speeds and runway exits while an aircraft is landing or aborting a takeoff. 5102 gets the last 5 positions reported and stored in the Aircraft Locations 20 Database [1010]. 5103 calculates the rate of change between the last 5 locations based on the timestamp of each location data. 5104 calculates the stopping location where the aircraft can safely exit the runway. 5105 extracts the next few exits beyond the stop location and 5106 assigns the first exit to the aircraft. 5107 sends the Pilot an exit selection Control Message through process 3001 [FIG. 3] and the Pilot can accept the route or select a different exit from 25 one of the other exits extracted in 5105. If a Pilot selects a different route through the CPDLCDU [140] as shown in FIG. 44 in 5108, 5109 will assign the exit selected by the Pilot.

[0215] FIG. 52 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating aircraft progress on a taxiway. 5202 retrieves the assigned route for the aircraft from either the Airport Departures database [1002] or the Airport Arrivals database [1003]. 5203 retrieves the current aircraft position. 5204 retrieves from 2308 the future anticipated positions for the aircraft until it completes the taxiing as used in FIG. 23. 5204 retrieves the last minute of data available for the aircraft future position. 5205 creates a timespan starting from the time the aircraft started the taxi operation and the anticipated remaining time in minutes until the taxi operation will be complete. The formula for the timespan is: timespan = minutes since start of operation + minutes till end of operation. 5206 calculates the position within the timespan in the form of a percentage (minutes elapsed from start divided by the total minutes for the taxi operation). For example, an aircraft exited a runway 5 minutes ago, and still has 15 minutes until it reaches the Gate. The timespan is 20 minutes of total time in taxi operation (5+15). Since 5 minutes have passed since the operation started, the result of the process is 25% (5/20).

[0216] FIG. 53 illustrates a flow diagram of the processes in a method within the AMS [320] involved with a Request Release operation from Departure ATC. 5302 receives the ATC responsible for giving the release. 5303 receives the aircraft position, and 5304 checks if the aircraft is anticipated to start the takeoff roll within two minutes. As long as the aircraft has more than two minutes until the takeoff roll, the condition is rechecked every 5 seconds 5305. Once the aircraft is anticipated to start the takeoff operation within the next two minutes, AMS [320] sends ICM [330] a release request message 5306, to display to the ATC for acceptance 5307 and sound a tone associated with a releaser request 1708. Once the ATC accepts the aircraft release request from the ICM [330] in 5309 over the ICM [330], the ICM [330] sends AMS [320] a message of release acceptance 5311, and sounds a tone to the ATC over the ICM [330] associated with a handoff acceptance 5313. Until ATC accepts the release in 5309, 5310 waits and redispalyes the release request 5307 and sounds the release request tone in 5308 every 5 seconds.
FIG. 54 illustrates a flow diagram of the processes in a method within the AMS [320] involved with determining if an aircraft cleared a junction. The method uses position reports from the APRS [353] located at the corners of the junction. 5402 retrieves the aircraft current location from the Aircraft Locations Database [1010]. 5403 retrieves all the APRS [353] at the junction in the area of the aircraft. 5404 retrieves from the Aircraft Locations Database [1010] any last reported positions from any of the APRS [353] in 5403. 5405 sorts all retrieved reported aircraft positions reported by the junction APRS [353] from 5403 in descending order, the result of the sort ensures the latest reports are first and the older reports are last. 5406 extract the first two APRS [353] that are different within the sorted list of positions as sorted by 5405. 5407 compares the two APRS [353] from 5406 and checks if they are within the same junction. If the output from 5407 is true the junctions APRS [353] and the aircraft cleared the Junction. 5408 and the process is terminated. As long as the output from 5407 is false, the aircraft did not clear the junction yet 5410 and the method will wait 5 seconds 5411 and re-execute from 5402 until 5407 is true.

FIG. 55 illustrates a flow diagram of the processes in a method within the AMS [320] involved with calculating junction congestions and hotspots levels. Method compares expected congestions from FIG. 23 with normal congestion levels. 5502 retrieves the latest data from 2313 [FIG. 23] with anticipated congestion levels and hotspots for all junctions. 5503 retrieves the normal congestion levels for each of the junctions from the Airport layout database [1001]. 5504 compares each of the current and anticipated junction congestion levels from 5502 with the normal congestion levels from 5503. 5505 discards all current and future congestions that are lower than the normal congestions by at least twenty percent, ensuring any congestions close to the normal congestion levels by twenty percent or higher are handled by the system. 5506 sorts the current and future congestion levels. 5507 stores the results for future reference in 5508.

FIG. 56 illustrates a flow diagram of the processes in a method within the AMS [320] involved in LGRC [355] image processing for confirming locked gear of a landing aircraft. The method receives and compares images from the LGRC [355] to confirm the front landing gear is locked. The LGRC is positioned at an angle to capture as many images as possible for the verification. 5602 retrieves aircraft position from the Aircraft Locations Database [1010] and 5603 checks if the location is close to the area of the LGRC [355]. As long as the aircraft is not positioned within the lense of the LGRC [355] 5603, the method waits 100 milliseconds 5604 and retrieves again the aircraft position in 5602. Once the aircraft is known to be within the LGRC [355] lense in 5603, 5605 imports the next available image from the LGRC [355] and 5606 processes the image to focus on the front nose of the aircraft including the landing gear. 5607 rotates the image of the image to compensate for the angle of the lense in relation to the bottom of the aircraft. 5608 resizes the image to a unified width and height as all other images for comparison. 5610 compares the incoming image with the last image within the images stored in 5609. If the comparison in 5610 output is true the image is the same as the previously stored image in 5608 and process 5612 is executed until the aircraft has passed the LGRC lense. If the comparison in 5610 output is false the image is not the same as the previously stored image in 5608 and 5611 stores the image in 5608 for future comparison. 5612 calculates if the aircraft has passed the range of the lense. Once the aircraft has passed the lense in 5612, 5613 compares all the images stored within
5609. After the correction in 5607, when gear is locked, 5609 should only have a single image or all images are within acceptable deviation for an error factor, if the gear is not locked, the difference in deviation between the images is high. 5613 calculates the total deviation of error factors between all the images and 5614 decides if the gear is locked based on the error factor output from 5613. As long 5614 output is true, the gear is locked and the method is complete. 5615 sends a Control Message using process 3001 [FIG. 3] to alert the pilot, and 5616 dispatches emergency personnel using process 3201 [FIG. 32]. In addition, the ICM [330] notifies ATC with a landing gear warning and 5618 sounds the notification tone associated with the landing gear warning.

[0220] FIG. 57 illustrates a flow diagram of the processes in a method within the AMS [320] involved in issuing a "hold short" ATC command to an aircraft. A "hold short" directive is given near junctions while an aircraft is taxiing. 5702 retrieves the current location of the aircraft from the Aircraft Locations Database [1010]. 5403 retrieves the closest junctions APRS [353] within the routing path of the aircraft from the Airport Layout database [1001]. If there are no close junction APRS[353] in 5704, the aircraft is not close to a junction and 5705 waits for 5 seconds and retries 5702. Once the aircraft is near at least one junction APRS [353] in 5704, 5706 retrieves all other aircrafts close to the junction from the Aircraft Locations Database [1010]. If the junction involves a runway 5707, the aircraft must hold short of the runway junction at all times and 5708 sends a "Hold Short" Control Message through process 3001 [FIG. 3] for the flight crew through the CPDLCDU [140] and 5709 generates "Hold Short" over the radio frequency for the flight crew. If the junction does not cross a runway 5707, 5710 further checks for other possible aircraft near the junction. If the output of 5710 is false, the aircraft can cross the runway, 5714 sends a "Hold Short" Control Message through process 3001 [FIG. 3] for the flight crew through the CPDLCDU [140] and 5715 generates "Hold Short" over the radio frequency for the flight crew. If other aircrafts are near the junction in 5710, 5711 further checks if the aircraft has a priority, if it does not have priority the aircraft must hold short of the junction at all times and 5708 sends a "Hold Short" Control Message through process 3001 [FIG. 3] for the flight crew through the CPDLCDU [140] and 5709 generates "Hold Short" over the radio frequency for the flight crew. If the aircraft does have priority over other aircrafts for crossing the junction in 5711, the aircraft can cross the runway and 5712 sends a "Cross" Control Message through process 3001 [FIG. 3] with the additional information that traffic will make way, and 5709 generates "cross" over the radio frequency with the additional information that traffic will make way. The method is always executing for every aircraft as long as the aircraft has not completed its taxiing [FIG. 52].

[0221] FIG. 58 illustrates a flow diagram of the processes in a method within the AMS [320] involved with runway capacity balancing and takeoff to landing ratios. Aside from calculating the takeoff to landing ratios for each runway, the method reroutes future takeoffs to other runways or opens an additional runway if the runway is expected to be over capacity. 5802 retrieves all the available runways from the Airport Layout Database [1001], 5803 filters only for the active runways. 5804 retrieves all departures that have not started taxiing yet from the Airport Departures Database [1002] for each runway, and 1003 retrieves all the expected landings from the Airport Arrivals Database [1003] for each runway. Once the data is available, 5806 sorts all
landings and takeoff data for each runway. 5807 calculates the number of takeoff and landing operations expected for each runway. 5808 calculates the takeoff to landing ratio for each runway. 5809 calculates the overall time for all expected operations versus the capacity of the runway, the output is a percentage of the expected operations in relation to the capacity (total operations time divided by capacity). 5810 checks for overcapacity from the output of 5809. If there is no overcapacity expected for a runway, 5811 checks if there are more runways to calculate. If there are, 5807 is executed again, if 5811 output is false, there are no more runways to check and the method is complete. If the capacity was exceeded in 5810, 5813 checks for available runways that are not at capacity and can handle more takeoffs. If they are 5814, 5815 diverts future takeoffs to that runway, as long as the diverted takeoffs have not left the gate yet for taxiing to the original runway. After 5815 reassigns future takeoffs, 5811 checks if there are more runways to calculate. If there are, 5807 is executed again, if 5811 output is false, there are no more runways to check and the method is complete. If there were no available runways to handle the overcapacity in 5815, 5816 checks if there are any available runways that can be opened. If there are, 5817 will open a new runway and use process 5815 to divert takeoffs as stated above in 5815. If there are no runways that can be opened, 5815 diverts future takeoffs as stated above, and ensures there is a balance in runway capacity at any given time when at least one runway is at overcapacity.

[0222] FIG. 59 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of breaking action. The method processes the data sent by a Pilot via the CPDLCDU [140] and stores it into the database for future use in runway operations. 5902 retrieves the aircraft type and runway used, 5903 decodes the button pressed on the CPDLCDU [140] for the associated data. 5904 stores in the Runway Conditions Database [1011] the following data: runway; time of report; aircraft type; reported breaking condition. The data is used for issuing breaking condition notification to other pilots during landing operations on the CPDLCDU [140], an example is the "GOOD BRKNG BY 757 [3MIN]" in FIG. 39 telling the Pilot the last reported breaking action on the runway was good and was reported 3 minutes ago by a Boeing 757.

[0223] FIG. 60 illustrates a flow diagram of the processes in a method AMS [320] involved with Pilot report of runway conditions. The method processes the data sent by a Pilot via the CPDLCDU [140] and stores it into the database for future use in runway operations. 6002 retrieves the aircraft type and runway used, 6003 decodes the button pressed on the CPDLCDU [140] for the associated data. 6004 stores in the Runway Conditions Database [1011] the following data: runway; time of report; aircraft type; reported runway condition. The data is used for runway condition notification to other pilots during landing operations on the CPDLCDU [140], an example is the "WET RWY" in FIG. 39 telling the Pilot the runway condition is wet.

[0224] FIG. 61 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of birds. The method processes the data sent by a Pilot via the CPDLCDU [140] and stores it into the database for future use in runway operations. 6102 retrieves the aircraft type and runway used, 6103 decodes the button pressed on the CPDLCDU [140] for the associated data. 6104 stores in the Runway Conditions Database [1011] the following data: runway; time of report; aircraft type; reported location of
birds. The data is used for issuing bird alerts to other pilots during takeoff and landing operations on the CPDLCDU [140].

[0225] FIG. 62 illustrates a flow diagram of the processes in a method within the AMS [320] involved with Pilot report of debris on a runway. The method processes the data sent by a Pilot via the CPDLCDU [140] and stores it into the database for future. 6202 retrieves the aircraft type and runway used, 6203 decodes the button pressed on the CPDLCDU [140] for the associated data. 6204 stores in the Runway Conditions Database [1011] the following data: runway; time of report; aircraft type; reported location of debris.

[0226] FIG. 63 illustrates a flow diagram of the processes in a method within the AMS [320] involved with taking over an aircraft and activating the autopilot. The method is executed automatically and is managed by ATC through the ICM [330]. 6302 retrieves the aircraft data from the Aircraft Location Database [1010] including: squawk code, location; altitude; speed; heading; and route if available. 6303 checks if the aircraft is squawking a distress code. If the squawk code is normal and the aircraft is not deviating from the route, the method is terminated. If the aircraft is deviating from its planned course or is squawking for distress, 6305 checks if the automated takeover is allowed, the setting for automated takeover is managed by ATC through the ICM [330]. If the automated takeover is not allowed, 6308 a warning is displayed to the ATC through the ICM [330] in 6308 and a tone associated to a takeover failure will sound through the ICM [330] to alert the ATC of failure in the aircraft takeover attempt. If the automated takeover is allowed in 6305, to avoid unauthorized use of the takeover a secondary facility authorizes the takeover process 6306, 6307 sends a "autopilot on" Control Message through process 3001 [FIG. 3] directly to the FANS [120J/FMS [130] to turn on the autopilot [150] and lock it in case of human tampering onboard the aircraft. 6312 receives a response code from the aircraft avionics, if the response is a false, the ATC will be notified as above of the failure in the takeover attempt. If the response in 6312 is true, the autopilot [150] is turned on, and can only be managed from the ground until the autopilot [150] is turned off. While the autopilot [150] is on, 6313 waits for execution of commands until new command is sent to the autopilot [150] to execute. 6314 processes the required changes in the flight path including: altitude; heading; speed; vector; route; or flight plan. If there are changes to be sent to the aircraft 6315, 6316 sends a "flight plan" Control Message using process 3001 [FIG. 3] telling the aircraft what to execute. The process of 6312 through 6315 continues until the aircraft landed or the autopilot [150] is turned off or until a continuous error occurs in sending the Control Messages in 6316.

[0227] FIG. 64 illustrates a flow diagram of the processes in a method within the AMS [320] involved with grounding all airborne aircrafts. The method is used in the event of terrorist attack similar to 9/11 where all airborne aircraft must be grounded as soon as possible. The system efficiently tries to takes over all aircraft close the airport and land them [FIG. 63]. Each airport grounds the aircrafts within its area. 6402 retrieves all airborne aircraft that can land at the airport. 6403 tries to turn on the autopilot [150] of each aircraft and send a flight plan to land at the airport using Process 6301 [FIG. 63]. 6404 receives all the error codes from the takeover attempt in 6403 and adds them to a list. 6405 displays the list of the aircraft that need to be contacted manually by ATC for landing them at the airport. 6405 sounds the takeover fail tone to notify the ATC of the
list created in 6404. This method is intended to considerably lower the workload of ATC as nearly all commercial aircraft near major airports are automatically grounded by the system.

[0228] FIG. 65 lists all common terms and their related codes used throughout this document.

[0229] FIG. 96 illustrates a flow diagram of the processes in a method within the AMS [320] involved with filtering and merging data to produce a single dynamic airport map as an image, the image is processed and sent for display aboard DAMS [141]. 9602 fetches all traffic in surrounding area or future on-route traffic that me affect aircraft operations, 9603 fetches all physical data on available nearby and on-route to destination, taxiways, junctions, runways, restricted areas, that may be of use to the aircraft in the future to reach final destination within aerodrome. 9604 fetches list of available data of all full taxi routes as well as progressive routing that may be of use, 9605 filters the data depending on area of operation and operation type. It is important to stress that the reason for not processing the data aboard the aircraft is due to several factors such reliability since incorrect or incomplete data due to loss of communication and is not refreshed in realtime, and therefore, deemed unsafe and unusable. 9606 filters only for runway data, and 9607 adds possible exits for takeoff and landing operations. If the operation is not related to a runway, 9708 computes distances and times to nearby or junctions assigned within a route, all data is filtered to only consider a set area in respect to aircraft position and operation. 9610, applies all notifications affecting the area being displayed, such as constructions, birds, FOD and alike. 9611 calculates the anticipated time of the next command or operation to be given to the pilot, to increase situational awareness and capacity on each runway, junction and taxiway. In addition, the timer calculates optimal taxi speed to reduce variance in engine power consumption, and to time the speed in order to minimize the slowdown at junctions, possibly to the point of being able to continue a junction crossing without stopping or even slowing the aircraft. 9612 applies all filtered collected data into an image overlay on an airport satellite image or airport diagram as preferred by the pilot. 9613 adds possible menus related to current operation or as requested by the pilot, 9614 stores all possible points that may be clicked on the screen for referencing future interaction sent back to the system for processing. 9615 ultimately creates a final compressed and encrypted image to be decrypted by DAMS [161]. 9616, uses the AGC [610] as shown in Fig. 4 , to send the data as a control message to the CCS [160] onboard the aircraft. It is important to note that portions of this method are used by the methods related to marshalling aircraft breaks, steering and engine power as shown in Fig. 97 and Fig. 98, as well as other methods that require timing information for junctions and taxiway operations.

[0230] FIG. 97 illustrates a flow diagram of the processes in a method within the AMS [320] involved with marshalling breaks of an aircraft if it is moving in the wrong direction or is not stopping at the proper location. 9702 gathers aircraft position, speed and heading, while accounting for previous historical positioning and speed data, as well as instruction to be executed, 9703 decides if the aircraft needs to be stopped. 9704 notify the pilot via a DAMS [140] warning that the aircraft breaks are being marshalled. 9805 sends DAMS [140] a control message from the AMS [320] to pass to the breaking system aboard the aircraft as a control message, to apply breaks until a full stop is achieved. 9706 also notifies the commanding ATC of the marshalling, and
is alerted in the ICM[330] of the location and aircraft, to enable the commanding ATC to further examine the
nearby traffic and make additional overrides if needed.

[0231] FIG. 98 illustrates a flow diagram of the processes in a method within the AMS [320] involved with
marshalling steering and engine power aboard an aircraft if it is moving in the wrong direction or needs to me
moved, in cases such as not fully clearing a junction, or not expediting a command. The same process and
command control as Fig. 97 are used, but the control message is sent to the onboard steering system and/or the
engine power system. 9808 constantly checks if the required position goal is achieved, and repeats the process
until the desired position and/or engine power is produced. The control is given back to the pilot after the
marshalling was completed or, if better performance was produced by the pilot.

[0232] FIG. 99 illustrates a possible embodiment for displaying the dynamic map, where a pilot can select a
map diagram instead of a satellite image.

[0233] FIG. 100 illustrates an example of the numerous of supported interface protocols, data models,
scripting and framework standards.

[0234] FIG. 101 illustrates an example of the process used to capture pilot interaction with DAMS[161], and
send the interaction as a control message to AMS [320] for processing. 10102 captures the position of the user
interaction, and the number of clicks in the area of the initial click. 10103 converts the touch location and
number of interactions as text. 10104 stores the message text. 10105 converts the text to a control message
format, is encrypted by 10106 and sent by 10107 to the AMS[320] for decryption and further processing.

[0235] Fig. 102 illustrates an example of the process used to capture a pilot voice command or request and
send it to the AMS [320] for processing, including the conversion of the input voice as text, and sending it as a
control message as discussed in Fig. 101.

[0236] Fig. 103 illustrates an example of the process used to capture data from avionics, and cockpit
conversations, to be stored on the ground, in case there is a need to replay the information in relation to other
nearby sensors and aircrafts. Any data captured from avionics, or sound within the cockpit is sent as a control
message to the AMS [320] and stored on the server[300] as required by governing bodies.
What is claimed is:

1. A computer implemented method for automatic management of airport air traffic control, the method comprising:
   a) automatically generating and exchanging control messages of data information between the airport air traffic control and a specific aircraft's pilot via a data link connecting the airport air traffic control system and the interface and control systems within the airplane by executing a selected predefined control message;
   b) automatically generating and exchanging control and data voice messages between the airport air traffic control and plurality of aircraft's pilots via voice communication channels connecting the airport air traffic control system and the interface and control systems within the airplane by executing a selected predefined control message;
   c) continuously updating information on the position of all airplanes within the control zone of the airport air traffic control from airborne avionics and ground sensors;
   d) continuously updating information regarding the status of the runways, junctions, taxiways, weather conditions, debris, birds within the control zone of the airport air traffic control from authorized reporting bodies such as controllers, pilots, external systems;
   e) displaying operational information on cockpit display according to the flight stage of the aircraft and relevant airport traffic;
   f) enabling the pilot to send requests and/or responses over voice channels or data link channels;
   g) recording all information exchanged via the audio and data communication channels, all sounds within the cockpit, flight performance data from aircraft sensors and avionics; and
   h) displaying information to the controller and enabling him to manage related associated airport automated operations either by touch screen, data entry, mouse or by hand gestures.

2. The method of claim 1, further comprising the steps of:
   a) performing voice recognition on voice messages received from aircraft's pilot;
   b) automatically converting received message to text message; and
   c) automatically synthesizing text to speech.

3. The method of claim 2, further comprising the step of translating messages from English to pilot's native language and vice versa.

4. The method of claim 1, wherein a control message transmitted via data link can be text messages, graphics, pictures, or binary data.

5. The method of claim 1, wherein each predefined control message includes receiving of indication whether a command sent to an aircraft has been accepted or rejected.
6. The method of claim 1, wherein moving map of the airport is displayed on flight deck display during landing, taking-off, and taxiing.

7. The method of claim 1, wherein data link information exchanged between the airport air traffic control and aircrafts or other air traffic controls is encrypted by information sender and is decrypted by information receiver.

8. A computer implemented method for automatic management of airport air traffic control, the method comprising:
   a) automatic hand-off of control between airport air traffic control and another air traffic control;
   b) providing continuous verbal and visual information and commands to plurality of aircrafts during landing;
   c) providing continuous verbal and visual information and commands to plurality aircrafts during take-off;
   d) providing continuous verbal and visual information and commands to plurality of pilots during taxiing;
   e) taking control of the aircraft in case of hijacking or emergency situation by sending data to the automatic pilot and flight management computer on said aircraft; and
   f) managing the dispatching of emergency personnel and providing them continuous information on preferred standby position, and relevant information; and
   g) balancing the use of multiple runways by evaluating anticipated traffic load, weather and operational conditions.

9. The method of claim 8, further comprising the steps of:
   a) providing lineup and wait command to aircraft via voice and data link channels;
   b) providing takeoff information comprising of: runway conditions; weather; birds; debris; emergency exists; expected time until airborne; mav sid or initial climb, heading and departure contact information;
   c) providing takeoff clearance command via voice and data link channels;
   d) providing rolling updates via data link channels; and
   e) providing turbulence warning if required.

10. The method of claim 8, further comprising the steps of:
    a) providing landing clearance command via voice and data link channels;
    b) providing braking updates information comprised of: runway conditions; birds; debris; relevant exits and distance from current location;
    c) providing turbulence warning if required;
    d) flashing airfield lights of exit to take;
    e) generating of go-around suggestion approach command if required by analyzing landing situation;
    f) generating of missed approach command if required by analyzing landing situation; and
The method of claim 8, further comprising the steps of:

a) predicting congestion and hotspots on taxiways;

b) selecting preferred takeoff junction on long runways for departing aircraft;

c) recommending to pilot preferred taxiing routes with anticipated taxiing time;

d) monitoring landing aircraft on the runway and recommend next exit junction;

e) selecting landing aircraft preferred taxiing route;

f) displaying updated position and countdown timers within the route to the pilot on the dynamic airport map in the cockpit; and

g) monitoring the taxiing of the aircraft.

The method of claim 8, further comprising the steps of:

a) controlling junction crossing of aircrafts and vehicles; and

b) monitoring junction crossing.

The method of claim 8, further comprising the steps of:

displaying a colored dynamic airport map to pilot, said map displays updated surrounding traffic in the air and on the ground.

The method of claim 8, further comprising the step of generating control commands and managing grounding of all aircrafts in case of emergency.

The method of claim 8, further comprising the steps of:

marshaling breaks or steering and engine power upon detection of dangerous situations, such as aircraft continues to move past a specified holding position, or too slow clearing of a junction.

The method of claim 8, further comprising the steps of:

a) performing automatic hand-off from approach ATC after receiving hand-off request;

b) generating hand-off request to departure ATC and automatically managing the hand-off procedure.

An airport air traffic control system comprising:

a) plurality ground based server processor;

b) airport air traffic management software package executed on said server;

c) plurality of ground based sensors functionally coupled to said server;

d) plurality of voice and data communication equipment coupled to said server;

e) plurality of computerized terminals coupled to said server;

f) plurality of aircrafts communicatively coupled to said server via airborne communication equipment;

and

g) display and control units within each aircraft coupled to said airborne communication equipment; and

h) ground vehicles communicatively coupled to said server via said voice and data communication equipment; and

monitoring the taxiing of the aircraft.
i) airfield lights system, controlled by said server.

18. The airport air traffic control system of claim 17 whereas ground based sensors are comprised of:
   a) plurality of radar units;
   b) plurality of movement detection cameras providing information on aircraft location;
   c) plurality of aircraft position reporting sensors;
   d) plurality of landing gear reporting cameras.

19. The airport air traffic control system of claim 17 whereas computerized terminals are comprised of:
   a) strategic airline monitoring module exchanging flight information with airport air traffic management software;
   b) plurality of controller interface terminal enabling a controller to remotely communicate with airport air traffic management software and send commands and data;
   c) airport operations center module for exchanging aircraft and airport scheduling with the airport management software;
   d) plurality of air traffic control terminals running software package that enables automatic handoff of control;
   e) plurality of emergency dispatch modules.

20. The airport air traffic control system of claim 17 whereas the display and control units within each aircraft are comprised of:
   a) future air navigation system (FANS) communicatively coupled to ground communication equipment;
   b) controller pilot data link communication (CPDLC) unit communicatively coupled to ground communication equipment and to said FANS;
   c) controller pilot data link communication display unit (CPDLCDU) functionally connected to said CPDLC capable of displaying text and graphics and functional keys;
   d) autopilot system coupled to said FANS;
   e) a flight management system (FMS) coupled to said autopilot, FANS and CPDLC units;
   f) a cockpit computer system (CCS) communicatively coupled to ground communication equipment and to FANS and avionics through FANS, said cockpit computer is capable of displaying dynamic airport map, the map is in color and relevant information is superimposed on said map;
   g) a software package executed within the CCS for displaying dynamic airport map.
Hardware, computers and devices

FIG. 1
Send Control Message

3001 Start

3002 Process incoming request

3003 Process data based on Control Message type

3004 Format Message structure based on Control Message type

3005 Dynamically encrypt data

3006 Send Control Message to FANS / FMS / CPDLC / DAMS depending on type

3007 Receive decryption confirmation by FANS / FMS / CPDLC / DAMS

3008 Success?

3009 For FANS / FMS?

3010 FANS / FMS executes Control Message

3012 CPDLCU / DAMS displays data

3014 Send Control Message to AMS with Error Info

3011 Success?

3015 Sound notification?

3016 Sound a notification tone

3013 Success?

3017 End

FIG. 3a
Send Control Message to DAMS

3101 Start

3102 Process incoming request

3103 Process data based on Control Message type

3104 Dynamically encrypt data

3105 Send Control Message to DAMS

3106 Receive decryption confirmation by DAMS

3107 Format Message structure based on Message type

3108 Translate content to pilot's language if not English

3109 Message to speech?

3110 Output Synthesized message over speaker

3111 Sound notification?

3112 Sound a notification tone

3113 End

FIG. 3b
### Outgoing Control Message Types

<table>
<thead>
<tr>
<th>CODE</th>
<th>SENT TO</th>
<th>TYPE</th>
<th>EXAMPLE OF ADDITIONAL DATA / NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001</td>
<td>CPDLCDU</td>
<td>Runway hold short</td>
<td>runway or junction name (optional expedite)</td>
</tr>
<tr>
<td>1002</td>
<td>CPDLCDU</td>
<td>Cross runway</td>
<td>runway or junction name (optional expedite)</td>
</tr>
<tr>
<td>1003</td>
<td>CPDLCDU</td>
<td>lineup and wait</td>
<td>runway, RNAV / climb info, time till takeoff clearance</td>
</tr>
<tr>
<td>1004</td>
<td>CPDLCDU</td>
<td>pre-takeoff information</td>
<td>turbulence, winds, runway, RNAV / climb info</td>
</tr>
<tr>
<td>1005</td>
<td>CPDLCDU</td>
<td>takeoff Clearance</td>
<td>turbulence, winds, runway, RNAV / heading and altitude</td>
</tr>
<tr>
<td>1006</td>
<td>CPDLCDU</td>
<td>takeoff information</td>
<td>turbulence, winds, runway, RNAV / heading and altitude</td>
</tr>
<tr>
<td>1007</td>
<td>CPDLCDU</td>
<td>rolling update</td>
<td>updated data for turbulence, winds, abort exits</td>
</tr>
<tr>
<td>1008</td>
<td>CPDLCDU</td>
<td>airborne departure</td>
<td>departure frequency and contact altitude</td>
</tr>
<tr>
<td>1009</td>
<td>CPDLCDU</td>
<td>departure handoff</td>
<td>departure frequency and contact altitude</td>
</tr>
<tr>
<td>1051</td>
<td>CPDLCDU</td>
<td>no landing gear</td>
<td>Note: no gear detected, Pilot needs to recheck gear is out</td>
</tr>
<tr>
<td>1052</td>
<td>CPDLCDU</td>
<td>unconfirmed gear</td>
<td>Note: Pilot needs to recheck gear is out</td>
</tr>
<tr>
<td>1053</td>
<td>CPDLCDU</td>
<td>Landing gear not locked</td>
<td>Note: the Landing Gear is unlocked. Pilot needs to recheck</td>
</tr>
<tr>
<td>1054</td>
<td>CPDLCDU</td>
<td>unconfirmed gear lock</td>
<td>Note: Pilot needs to recheck of Landing Gear is locked</td>
</tr>
<tr>
<td>1055</td>
<td>CPDLCDU</td>
<td>landing clearance</td>
<td>turbulence, winds, runway, expected exit (full runway option)</td>
</tr>
<tr>
<td>1056</td>
<td>CPDLCDU</td>
<td>go-around</td>
<td>optional climb heading / and departure contact info</td>
</tr>
<tr>
<td>1057</td>
<td>CPDLCDU</td>
<td>missed approach</td>
<td>optional climb heading / and departure contact info</td>
</tr>
<tr>
<td>1058</td>
<td>CPDLCDU</td>
<td>Full runway</td>
<td>runway</td>
</tr>
<tr>
<td>1059</td>
<td>CPDLCDU</td>
<td>Exit runway</td>
<td>runway / taxiway / junction, (optional handoff contact info)</td>
</tr>
<tr>
<td>1060</td>
<td>CPDLCDU</td>
<td>Ground handoff</td>
<td>frequency, at taxiway / junction (optional hold short)</td>
</tr>
<tr>
<td>1071</td>
<td>CPDLCDU</td>
<td>Runway closed</td>
<td>runway / junction</td>
</tr>
<tr>
<td>1072</td>
<td>CPDLCDU</td>
<td>Runway open</td>
<td>runway / junction</td>
</tr>
<tr>
<td>1101</td>
<td>CPDLCDU</td>
<td>follow</td>
<td>runway / taxiway / junction, (optional &quot;company&quot;), aircraft type</td>
</tr>
<tr>
<td>1102</td>
<td>CPDLCDU</td>
<td>give way</td>
<td>runway / taxiway / junction, (optional &quot;company&quot;), aircraft type</td>
</tr>
<tr>
<td>1103</td>
<td>CPDLCDU</td>
<td>will give way</td>
<td>runway / taxiway / junction, (optional &quot;company&quot;), aircraft type</td>
</tr>
<tr>
<td>1104</td>
<td>CPDLCDU</td>
<td>not a factor</td>
<td>taxiway junction name (optional expedite)</td>
</tr>
<tr>
<td>1105</td>
<td>CPDLCDU</td>
<td>cross taxiway</td>
<td>taxiway junction name (optional expedite)</td>
</tr>
<tr>
<td>1106</td>
<td>CPDLCDU</td>
<td>taxiway hold short</td>
<td>runway and taxiway or junction name (optional expedite)</td>
</tr>
<tr>
<td>1107</td>
<td>CPDLCDU</td>
<td>Runway handoff</td>
<td>frequency, at Runway / junction (optional hold short)</td>
</tr>
<tr>
<td>1108</td>
<td>CPDLCDU</td>
<td>birds</td>
<td>runway, area / altitude</td>
</tr>
<tr>
<td>1109</td>
<td>CPDLCDU</td>
<td>debris</td>
<td>runway, position / junction, type</td>
</tr>
<tr>
<td>1110</td>
<td>CPDLCDU</td>
<td>Taxiway closed</td>
<td>taxiway / junction</td>
</tr>
<tr>
<td>1111</td>
<td>CPDLCDU</td>
<td>Taxiway open</td>
<td>taxiway / junction</td>
</tr>
<tr>
<td>2001</td>
<td>FMS/FANS</td>
<td>Autopilot on</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>FMS/FANS</td>
<td>Autopilot off</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>FMS/FANS</td>
<td>Flight Plan</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>FMS/FANS</td>
<td>Force execute</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>FMS/FANS</td>
<td>RNAV</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>FMS/FANS</td>
<td>Go Around</td>
<td>Note: optional altitude / heading</td>
</tr>
<tr>
<td>2007</td>
<td>FMS/FANS</td>
<td>Missed Approach</td>
<td>Runway, published approach</td>
</tr>
</tbody>
</table>

**FIG. 5**
### Incoming Control Message Types

<table>
<thead>
<tr>
<th>CODE</th>
<th>FROM</th>
<th>TYPE</th>
<th>EXAMPLE OF ADDITIONAL DATA / NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1501</td>
<td>CPDLCDU/DAMS</td>
<td>lineup unable</td>
<td></td>
</tr>
<tr>
<td>1502</td>
<td>CPDLCDU/DAMS</td>
<td>lineup not ready</td>
<td>time till ready</td>
</tr>
<tr>
<td>1503</td>
<td>CPDLCDU/DAMS</td>
<td>rolling unable</td>
<td>time till ready</td>
</tr>
<tr>
<td>1504</td>
<td>CPDLCDU/DAMS</td>
<td>takeoff abort</td>
<td></td>
</tr>
<tr>
<td>1505</td>
<td>CPDLCDU/DAMS</td>
<td>full runway request</td>
<td></td>
</tr>
<tr>
<td>1506</td>
<td>CPDLCDU/DAMS</td>
<td>breaking action</td>
<td>runway, breaking action</td>
</tr>
<tr>
<td>1507</td>
<td>CPDLCDU/DAMS</td>
<td>runway conditions</td>
<td>runway, condition</td>
</tr>
<tr>
<td>1507</td>
<td>CPDLCDU/DAMS</td>
<td>birds</td>
<td>runway, area / altitude</td>
</tr>
<tr>
<td>1508</td>
<td>CPDLCDU/DAMS</td>
<td>debris</td>
<td>runway, position / junction, type</td>
</tr>
<tr>
<td>1901</td>
<td>CPDLCDU/DAMS</td>
<td>confirm</td>
<td>Note: confirmation button was pressed on CPDLCDU</td>
</tr>
<tr>
<td>1902</td>
<td>CPDLCDU/DAMS</td>
<td>cancel</td>
<td>Note: cancel button was pressed on CPDLCDU</td>
</tr>
<tr>
<td>1903</td>
<td>CPDLCDU/DAMS</td>
<td>previous</td>
<td>Note: previous screen was requested on CPDLCDU</td>
</tr>
<tr>
<td>1904</td>
<td>CPDLCDU/DAMS</td>
<td>checksum error</td>
<td>Note: need to resend</td>
</tr>
<tr>
<td>1905</td>
<td>CPDLCDU/DAMS</td>
<td>unknown code</td>
<td>Note: CPDLCDU does not support the command code</td>
</tr>
<tr>
<td>1906</td>
<td>CPDLCDU/DAMS</td>
<td>unknown structure</td>
<td>Note: CPDLCDU could not decrypt the structure</td>
</tr>
<tr>
<td>1907</td>
<td>CPDLCDU/DAMS</td>
<td>unknown function</td>
<td>Note: The function is not supported by the CPDLCDU</td>
</tr>
<tr>
<td>1908</td>
<td>CPDLCDU/DAMS</td>
<td>unknown key</td>
<td>Note: An unknown key was pressed on the CPDLCDU</td>
</tr>
<tr>
<td>1909</td>
<td>CPDLCDU/DAMS</td>
<td>unknown destination</td>
<td>Note: no connection with CPDLCDU</td>
</tr>
<tr>
<td>1910</td>
<td>CPDLCDU/DAMS</td>
<td>unknown error</td>
<td>Note: an unknown error has occurred</td>
</tr>
<tr>
<td>2101</td>
<td>FMS/FANS</td>
<td>confirm</td>
<td>Hardware confirms the sent Control Command</td>
</tr>
<tr>
<td>2102</td>
<td>FMS/FANS</td>
<td>checksum error</td>
<td>Note: need to resend</td>
</tr>
<tr>
<td>2103</td>
<td>FMS/FANS</td>
<td>unknown code</td>
<td>Note: Hardware does not support the command code</td>
</tr>
<tr>
<td>2104</td>
<td>FMS/FANS</td>
<td>unknown structure</td>
<td>Note: Hardware could not decrypt the structure</td>
</tr>
<tr>
<td>2105</td>
<td>FMS/FANS</td>
<td>unknown data</td>
<td>Note: the hardware does not support the command data</td>
</tr>
<tr>
<td>2106</td>
<td>FMS/FANS</td>
<td>unknown destination</td>
<td>Note: no connection with hardware</td>
</tr>
<tr>
<td>2107</td>
<td>FMS/FANS</td>
<td>unknown error</td>
<td>Note: an unknown error has occurred</td>
</tr>
</tbody>
</table>

**FIG. 6**
### Supported ATC Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abort takeoff</td>
<td>ILS non-operational</td>
</tr>
<tr>
<td>Advise when able</td>
<td>ILS operational</td>
</tr>
<tr>
<td>Advise when ready</td>
<td>Landing gear locked</td>
</tr>
<tr>
<td>Advise when cleared junction</td>
<td>Landing gear not locked</td>
</tr>
<tr>
<td>Advise when cleared position</td>
<td>Lineup and wait</td>
</tr>
<tr>
<td>Advise when cleared runway</td>
<td>Make way</td>
</tr>
<tr>
<td>Advise when lined up</td>
<td>Missed-Approach</td>
</tr>
<tr>
<td>Cleared for immediate takeoff</td>
<td>Report cleared position</td>
</tr>
<tr>
<td>Cleared for immediate takeoff at</td>
<td>RNAV SID</td>
</tr>
<tr>
<td>Cleared for takeoff</td>
<td>Unconfirmed Landing gear lock</td>
</tr>
<tr>
<td>Cleared for takeoff at</td>
<td>VOR non-operational</td>
</tr>
<tr>
<td>Cleared to land</td>
<td>VOR operational</td>
</tr>
<tr>
<td>Climb to</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td></td>
</tr>
<tr>
<td>Confirm</td>
<td></td>
</tr>
<tr>
<td>Contact</td>
<td></td>
</tr>
<tr>
<td>Contact arrivals</td>
<td></td>
</tr>
<tr>
<td>Contact departure</td>
<td></td>
</tr>
<tr>
<td>Contact ground</td>
<td></td>
</tr>
<tr>
<td>Cross runway</td>
<td></td>
</tr>
<tr>
<td>Cross taxiway</td>
<td></td>
</tr>
<tr>
<td>Disregard</td>
<td></td>
</tr>
<tr>
<td>DME non-operational</td>
<td></td>
</tr>
<tr>
<td>DME operational</td>
<td></td>
</tr>
<tr>
<td>Expedite</td>
<td></td>
</tr>
<tr>
<td>Fly heading</td>
<td></td>
</tr>
<tr>
<td>Fly runway heading</td>
<td></td>
</tr>
<tr>
<td>Follow</td>
<td></td>
</tr>
<tr>
<td>Give way</td>
<td></td>
</tr>
<tr>
<td>Go-around</td>
<td></td>
</tr>
<tr>
<td>Heading</td>
<td></td>
</tr>
<tr>
<td>Hold short</td>
<td></td>
</tr>
</tbody>
</table>

**FIG. 7**

8/66
Lineup and wait

1101 START

1102 QUERY DATABASE FOR AIRCRAFT ON RUNWAY OR CLOSE TO LANDING

1010 AIRCRAFT LOCATION DATABASE

10104 IS AIRCRAFT PAST THE LINEUP AREA?

1103 AIRCRAFT ON RUNWAY OR CLOSE TO LAND?

1105 WAIT 5 SECONDS

1106 QUERY DATABASE FOR NEXT AIRCRAFT HOLDING SHORT OF RUNWAY FOR TAKEOFF

1107 CREATE A "LINEUP AND WAIT" CPDLC CONTROL MESSAGE

1108 SEND THE "LINE UP AND WAIT" MESSAGE TO THE CPDLC DU

1109 DISPLAY THE MESSAGE DATA ON THE CPDLC DU FOR THE FLIGHT CREW

1110 SAY A "LINE UP AND WAIT" ATC COMMAND ON ATC FREQUENCY

1111 END

FIG. 11
Takeoff Clearance

1201 Start

1202 Get aircrafts on runway

1203 Any aircraft on runway?
   YES
   1204 Get runway conditions, winds, breaking action, birds, debris
   1205 Get assigned RNAV SID or initial climb heading and Departure contact info for flight
   1206 Check if need to issue a turbulence warning from last operation in process 2601 [FIG. 26]
   1207 Send a “Takeoff Clearance” Control Message using process 3001 [FIG. 3]
   1208 Generate a “takeoff clearance” voice ATC command over ATC Radio frequency

1204 Wait 5 seconds

1209 End

FIG. 12
Landing Clearance

1301 Start

1302 Get aircrafts on runway

<table>
<thead>
<tr>
<th>YES</th>
<th>1303 Any aircrafts on runway?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>1304 Get runway conditions, winds, breaking action, birds, debris</td>
</tr>
</tbody>
</table>

1305 Get planned Gate, runway exit and Ground ATC contact information

1306 Check if need to issue a turbulence warning from last operation in process 2601 [FIG. 26]

1307 Send A “Landing Clearance” Control Message using process 3001 [FIG. 3]

1308 Generate a “Landing Clearance” voice ATC command over ATC Radio frequency

1309 Send A “Go Around” Control Message using process 1601 [FIG. 16]

1310 End

FIG. 13
Sending Rolling Updates

1401 Start

1402 Get runway exits in case the takeoff will be aborted

1001 Airport layout database
1010 Aircraft location database
1011 Runway conditions database

1403 Get aircraft Position

1404 Is the aircraft on the runway?

YES

1406 Get runway conditions, winds, breaking action, birds, debris

1407 Recalculate relevant exits if takeoff is aborted

NO

1405 End

1412 Wait 5 seconds

1408 Any changes since last message?

YES

1410 Store latest update data for later comparison

1411 Send A "Rolling Update" Control Message using process 3001 [FIG. 3]

NO

1409 Last Message

FIG. 14
Sending Breaking Updates

1501 Start

1502 Get runway exits for use during breaking operation

1503 Get aircraft position

1504 Is the aircraft still landing or breaking?

YES

1507 Get runway conditions, winds, breaking action, birds, debris

1508 Recalculate relevant exits using process 5101 [FIG. 51]

NO

1505 Stop flashing exit lights

1506 End

1510 Any changes since last message?

YES

1511 Store latest update data for later comparison

NO

1514 Wait 5 seconds

1513 Flash closest exit lights [FIG. 30]

1512 Send a “Breaking Update” Control Message using process 3001 [FIG. 3]

1509 Last Message

FIG. 15
Go-Around or Missed Approach

1601 Start

1602 Get climb information for Runway

YES

1603 Request is a Go-Around?

NO

1604 Send a “Go-Around” Control Message using process 3001 [FIG. 3]

1605 Generate a “Go-Around” voice ATC command over ATC Radio frequency

1606 ICM Displays “Go-Around” For Departure ATC

1607 ICM sounds a Go-Around tone for Departure ATC

1608 Flash the runway lights to notify Pilot not to land the aircraft [FIG. 31]

1609 End

1610 Send a “Missed Approach” Control Message using process 3001 [FIG. 3]

1611 Generate a “Missed Approach” voice ATC command over ATC Radio frequency

1612 ICM Displays “Missed Approach” For Departure ATC

1613 ICM sounds a Missed Approach tone for Departure ATC

FIG. 16
Handoff From Approach ATC

1701 Start

1702 ATC selects aircraft to handoff on ICM

1703 ICM sends a handoff request

1704 Get aircraft position and speed

1705 Calculate if distance from runway gives time for issuing landing clearance / go-around

1706 Enough time to handle aircraft?

1707 Return "handoff accepted" to ICM

1710 End

1711 Go-Around if refused?

1712 Return "handoff refused" to ICM

1713 ICM displays handoff refused to ATC

1714 ICM sounds a tone for refused handoff

1708 ICM displays accepted handoff to ATC

1709 ICM sounds a tone for handoff success

1715 Was a Go-Around?

1716 Send A “Go Around” Control Message using process 1601 [FIG. 16]
Handoff To Departure ATC

1801 Start

1001 Airport Layout Database

1802 Get latest Departure handoff altitude for the runway

1010 Aircraft Location Database

1803 Get aircraft position and altitude

1804 Aircraft reached handoff altitude?

1805 Wait 5 seconds

1806 Send ICM a handoff request for Departure ATC

1807 ICM displays handoff request to Departure ATC

1808 ICM sounds a tone associated with a handoff request

1809 ATC accepted handoff?

1810 Wait 5 seconds

1811 ATC accepts handoff through the ICM

1812 ICM returns “handoff accepted”

1813 ICM sounds a tone associated with handoff acceptance

1814 End

FIG. 18
Handoff From Ground ATC

1901
Start

1902
ATC selects aircraft to handoff on ICM

1903
ICM sends a handoff request

1904
Accept handoff and add to workload

1905
ICM displays accepted handoff to ATC

1906
ICM sounds a tone for handoff success

1907
End

FIG. 19
Handoff To Ground ATC

1. Start

2. Get Ground frequency related to handoff location

3. Get aircraft position

4. Aircraft reached handoff location?
   - NO: Wait 5 seconds
   - YES: Send ICM a handoff request for Departure ATC

5. ICM sounds a tone associated with a handoff request

6. ATC accepted handoff?
   - NO: Wait 5 seconds
   - YES: ATC accepts handoff through the ICM

7. ICM returns "handoff accepted"

8. ICM sounds a tone associated with handoff acceptance

9. End

FIG. 20
Timing runway crossings

2101 Start

2102 Get runway layout information with all junctions and exits

2103 Get any rolling or near touchdown aircrafts

2104 Any aircraft rolling or near touchdown?

YES

2105 Wait 5 seconds

NO

2106 Enough time to cross?

NO

2110 End

YES

2107 Send a "Cross runway" Control Message using process 3001 [FIG. 3]

2108 Generate a "Cross runway" voice ATC command over ATC Radio frequency

2109 Flash lights at Junction [FIG. 30]

FIG. 21
Managing Operations on Multiple Runways Simultaneously

2201 Start

2202 Get location of touchdown, lineup and exits for active runways

1001 Airport layout database

2203 Get taxiways and preferred taxiway routes

2204 Get time for next 10 landings for each runway

1010 Aircraft location database

2205 Get time for next 2 takeoffs for each runway

2206 Get latest runway conditions and breaking actions

2207 Recalculate time till airborne for next takeoff for each of the runways

2208 Any more takeoffs?

2209 End

NO

2210 Enough time for a takeoff?

YES

2211 Request release approval from Departure ATC using process 7001 [FIG. 70]

NO

2212 Departure approves release of takeoff?

YES

2213 Add the 15 degree variation for parallel runway operations if needed

2214 Process the takeoff is possible using process 1201 [FIG. 12]

FIG. 22
Predicting Taxiway Congestions And Hotspots

2301 Start

1001 Airport layout database

2302 Get runway layout information with all junctions and exits

1002 Airport departures database

2303 Get active runways

1003 Airport arrivals database

2304 Get scheduled departures

2305 Get scheduled arrivals

2306 Get assigned taxiway routes of all aircrafts

2307 Get current location of all aircrafts

2308 Future aircraft positions for every minute until reached destination

2310 Readjust the positions by compensating for aircrafts near a junction (based on the aircrafts at the junction)

2311 Rank taxiway congestions and junction hotspots by number of aircrafts on taxiway or at near a junction

2309 Calculate where each aircraft will be in next minute based on assigned route

2312 Store the congestion and hotspot data for taxiway routing processes

2313 Future Congestions and hotspots

2314 Done all minutes?

NO

YES

2315 End

FIG. 23
Avoiding Taxiway Congestions And Hotspots

2401 Start

2402 Get the origin and destination locations

2403 Get available routes from origin to destination

2404 Get the expected congestions and hotspots for each of the available routes [FIG. 23]

2312 Future Congestions and hotspots

2405 Rank routes based on fastest time to destination, congestion and hotspots

2406 Get airline’s preferred routes

2407 Decide on top 3 routes based on best match between the rank and the airline preference

2408 Assign best route

2411 Assign route selected by Pilot

2409 Send A “Routing selection” Control Message for CPDLC DU using process 3001 [FIG. 3]

2412 End

YES

2410 Pilot selected another route?

NO

FIG. 24
Maximizing Takeoff Operations On Long Runways

2501 Start

2502 Get assigned runway, aircraft type and required runway length

2503 Get the junctions of the assigned runway that can be used for a safe takeoff

2504 Assign a new takeoff starting for the departure

2505 Assign a preferred route based on new destination using process 2401 [FIG. 24]

2506 Recalculate estimated takeoff time

2507 End

FIG. 25
Turbulence Advisory

2601 Start

2602 Get aircraft type and current position of the last completed runway operation

2603 Is it a “HEAVY” class aircraft?

2605 Get current aircraft location

2606 Calculate the distance of the aircraft with the last completed runway operation

2607 Need a turbulence warning?

2608 Is this a takeoff?

YES

2609 Add a “turbulence warning” to the Command Message in process 1207 [FIG. 12]

NO

2610 Add a “turbulence warning” to voice ATC command in process 1208 [FIG. 12]

YES

2611 Add a “turbulence warning” to the Command Message in process 1312 [FIG. 13]

NO

2612 Add a “turbulence warning” to voice ATC command in process 1313 [FIG. 13]

2604 End

FIG. 26
CPDLCUD - Displaying And Allowing Pilot Confirmation

2701 Start

2702 Message is displayed by CPDLCUD in process 3012 [Fig. 3]

2703 Pilot pressed a button on CPDLCUD?

2704 Wait 5 seconds

2705 Sound notification tone

NO

YES

2706 Process the code from the button pressed on CPDLCUD

2707 Return the code

2708 End

FIG. 27
Recognize And Process Pilot Voice Over ATC Radio Frequency

2801 Start

2802 Convert voice to text using VTT plugin

2803 Get supported request types

2805 Any matches to the Request type?

NO

2804 Supported request types

YES

2807 Get associated request code

2808 Process code relation to information requested

2809 Is it a request?

NO

1011 Runway conditions database

YES

1001 Airport layout database

2810 Pull data related to request

2811 Text to Human-Voice

2812 Convert data to a human voice output file

2813 Play the voice file over the ATC radio frequency

2814 Is it a confirmation?

NO

2815 Return confirmation to the sending process

YES

2816 Execute the relevant process based on code

2806 End

FIG. 28
### Supported Pilot Voice Communication Over ATC Radio Frequency

<table>
<thead>
<tr>
<th>CODE</th>
<th>REQUEST SPEECH</th>
<th>CODE</th>
<th>REQUEST SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>with you</td>
<td>251</td>
<td>hold short / will hold short</td>
</tr>
<tr>
<td>202</td>
<td>wind-check</td>
<td>252</td>
<td>short of</td>
</tr>
<tr>
<td>203</td>
<td>roger</td>
<td>253</td>
<td>cross</td>
</tr>
<tr>
<td>204</td>
<td>wilco</td>
<td>254</td>
<td>crossing</td>
</tr>
<tr>
<td>205</td>
<td>routing available</td>
<td>255</td>
<td>expediting cross / expediting crossing</td>
</tr>
<tr>
<td>206</td>
<td>disregard</td>
<td>256</td>
<td>crossing complete</td>
</tr>
<tr>
<td>207</td>
<td>in good time</td>
<td>257</td>
<td>making way/make way/give way</td>
</tr>
<tr>
<td>208</td>
<td>unable</td>
<td>258</td>
<td>Follow</td>
</tr>
<tr>
<td>209</td>
<td>emergency</td>
<td>259</td>
<td>following</td>
</tr>
<tr>
<td>221</td>
<td>are we Cleared to land?</td>
<td>271</td>
<td>Lineup and wait / position and hold</td>
</tr>
<tr>
<td>222</td>
<td>cleared to land / to land</td>
<td>272</td>
<td>we are lined-up</td>
</tr>
<tr>
<td>223</td>
<td>full runway</td>
<td>273</td>
<td>ready for immediate</td>
</tr>
<tr>
<td>224</td>
<td>breaking action</td>
<td>274</td>
<td>RNAV SID set</td>
</tr>
<tr>
<td>225</td>
<td>Missed approach</td>
<td>275</td>
<td>rolling / on a roll</td>
</tr>
<tr>
<td>226</td>
<td>go-around</td>
<td>276</td>
<td>aborting / aborted takeoff aborted</td>
</tr>
<tr>
<td>227</td>
<td>cleared position / cleared the zebra</td>
<td>277</td>
<td>cleared for the takeoff</td>
</tr>
<tr>
<td>228</td>
<td>can we exit on / can we have</td>
<td>278</td>
<td>cleared for immediate takeoff</td>
</tr>
<tr>
<td>229</td>
<td>exit available / taxiway available</td>
<td>279</td>
<td>cleared for the takeoff at</td>
</tr>
<tr>
<td>230</td>
<td>cleared runway</td>
<td>280</td>
<td>cleared for immediate takeoff at</td>
</tr>
<tr>
<td>241</td>
<td>contact ground</td>
<td>291</td>
<td>climbing to</td>
</tr>
<tr>
<td>242</td>
<td>switching</td>
<td>292</td>
<td>departure at</td>
</tr>
<tr>
<td>243</td>
<td>runway available</td>
<td>293</td>
<td>can we lineup</td>
</tr>
<tr>
<td>244</td>
<td>Runway closed / Runway open</td>
<td></td>
<td></td>
</tr>
<tr>
<td>245</td>
<td>taxiway closed / taxiway open</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIG. 29**
Locations Of Runway Exit Lights

FIG. 30

Locations Of Runway Closed Flashing Lights

FIG. 31
Dispatching Emergency Personnel On Unlocked Landing Gear

3201 Start

3202 Get estimated aircraft touchdown and stopping area

3203 Get Emergency units related to touchdown and stopping areas

3204 Send a message to the EDM related to each Emergency unit

3205 EDM displays aircraft information and anticipated area to handle

3206 EDM sounds the emergency alarm [340] in the emergency unit

3207 End

FIG. 32
### CPDLCDU Screen types

<table>
<thead>
<tr>
<th>CODE</th>
<th>CPDLCDU SCREEN</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3201</td>
<td>hold short</td>
<td>winds, turbulence, birds, departure FREQ, RNAV SID or heading</td>
</tr>
<tr>
<td>3202</td>
<td>pre-lineup</td>
<td>winds, turbulence, birds, departure FREQ, RNAV SID or heading</td>
</tr>
<tr>
<td>3203</td>
<td>takeoff clearance</td>
<td>winds, turbulence, birds, RNAV SID or assigned climb heading</td>
</tr>
<tr>
<td>3204</td>
<td>rolling update</td>
<td>winds departure frequency and altitude</td>
</tr>
<tr>
<td>3205</td>
<td>airborne update</td>
<td>Departure frequency and contact altitude</td>
</tr>
<tr>
<td>3221</td>
<td>landing clearance</td>
<td>winds, turbulence, birds, expected exit, runway and breaking info</td>
</tr>
<tr>
<td>3222</td>
<td>breaking</td>
<td>expected exit and routing to gate</td>
</tr>
<tr>
<td>3223</td>
<td>missed approach</td>
<td>Missed-Approach or climb heading/altitude/FIX and departure frequency</td>
</tr>
<tr>
<td>3224</td>
<td>go-around</td>
<td>climb altitude and heading, departure frequency</td>
</tr>
<tr>
<td>3241</td>
<td>runway exit request</td>
<td>available exits</td>
</tr>
<tr>
<td>3242</td>
<td>taxiway routing request</td>
<td>available routing from current location to destination</td>
</tr>
<tr>
<td>3261</td>
<td>report breaking action</td>
<td></td>
</tr>
<tr>
<td>3262</td>
<td>report runway conditions</td>
<td></td>
</tr>
<tr>
<td>3263</td>
<td>report birds</td>
<td></td>
</tr>
<tr>
<td>3264</td>
<td>report debris</td>
<td></td>
</tr>
</tbody>
</table>

**FIG. 33**

### CPDLCDU - Pre Takeoff / Hold Short

![Diagram of CPDLCDU - Pre Takeoff / Hold Short](image)

**FIG. 34a**

33/66
**CPDLC MCU - Pre Takeoff / Lineup**

<table>
<thead>
<tr>
<th>LINEUP AND WAIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINDS 180 AT 3</td>
</tr>
<tr>
<td>RNAV SID LOREN</td>
</tr>
<tr>
<td>DEPARTURE 129.50 AT 2,000 FT</td>
</tr>
<tr>
<td>CAUTION WK TURB FROM DEPARTING 747</td>
</tr>
</tbody>
</table>

**LINING UP**

<table>
<thead>
<tr>
<th>1R</th>
<th>2R</th>
<th>3R</th>
<th>4R</th>
<th>5R</th>
<th>6R</th>
</tr>
</thead>
<tbody>
<tr>
<td>READY FOR T/O</td>
<td>UNABLE</td>
<td>MENU</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PREV**

**FIG. 35a**
CPDLCU - Takeoff Clearance

TAKEOFF CLEARANCE

WINDS 180 AT 3
CAUTION WK TURB FROM DEPARTING 747
RNAV SID LOREN
CLEARED FOR TAKEOFF 24L AT ALPHA
DEPARTURE 129.50 AT 2,000 FT
PREV

ROLLING
1R
2R
UNABLE
3R
ABORT
4R
5R
MENU
6R

FIG. 36a
**CPDLC DU - Rolling Update**

**ROLLING UPDATE**

- **WINDS 180 AT 5**
- **CAUTION WK TURB FROM DEPARTING 747**
- **RNAV SID LOREN**
- **DEPARTURE 129.5 AT 2,000 FT**

---

**FIG. 37a**
CPDLC DU – Airborne Update

AIRBORNE UPDATE

FLY HEADING 210
CLimb 3,000
CONTACT DEPARTURE 129.50 AT 2,000 FT

FIG. 38a
**CPDLC DU - Landing Clearance**

<table>
<thead>
<tr>
<th>1L</th>
<th>2L</th>
<th>3L</th>
<th>4L</th>
<th>5L</th>
<th>6L</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINDS 180 AT 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAUTION TURB FROM DEPARTING 747</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEARED TO LAND 24R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RWY WET, GOOD RKNG BY 757 [3 MIN]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXIT ON BRAVO AND 127.55 ON TOP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LANDING CLEARANCE**

- CLEARED TO LAND
- REQUEST EXIT
- REQUEST ROUTING
- MISSED APPROACH
- GO AROUND
- MENU

**FIG. 39a**
CPDLC DU - Breaking Update

BREAKING UPDATE

EXIT ON BRAVO [FLASHING LIGHTS]
CONATACT 127.55 ON TOP
PREV

CLEARED RWY
REQUEST EXIT
REQUEST ROUTING
REPORT BREAKING
REPORT RWY CONDITIONS
MENU

FIG. 40
CPDLC - Missed Approach

MISSED APPROACH

24R PUBLISHED MISSED APPROACH
CLIMB 3,000FT
DIRECT HERMA
CONTACT 127.80
PREV

SWITCHING
UNABLE
EMERGENCY
MENU

FIG. 41a

DA/MB - Missed Approach

S51160
MISSED APPROACH
CLIMB 3,000 FT
DIRECT HERMA
CONTACT 135.625

SWITCHING
UNABLE
EMER

FIG. 41b
CPDLC/CDU – Runway Exit Request

Runway Exit Request

FULL RUNWAY
ALPHA
DELTA
ECHO
PREV

FIG. 43a

Runway Exit Request

CAUTION TURB FROM
DEPARTING 747
WING 520 AT 5
CLEARED TO LAND 3R
Rwy wet; good braking by TF2 (3 min)
EXIT ON X AND 22555 ON TOP
FULL RUNWAY AVAILABLE
CANCEL EXIT
EXIT F1 - CONFIRM
REQUEST ROUTE
CLOSED APPROACH
GO AROUND
EMER

FIG. 43b
CPDLC DU – Routing Request

ROUTING REQUEST
11 MIN / MED - A1, 24R/ B, B5
12 MIN / LOW - Y3, 24R/C, C6
19 MIN / HIGH - D6, 24 R/D, D8

FIG. 44

CPDLC DU – Report Breaking Action

BREAKING ACTION REPORT
VERY GOOD
GOOD
AVERAGE
BAD
VERY BAD / NIL

FIG. 45
**CPDLCDU – Report Runway Conditions**

![Diagram of Runway Conditions Report]

**FIG. 46**

**CPDLCDU – Report Birds**

![Diagram of Bird Report]

**FIG. 47**
CPDLC DU – Report Debris

DEBRIS REPORT

LEFT SIDE – BEFORE TD
LEFT SIDE – AT TD
LEFT SIDE – MIDFIELD
LEFT SIDE – DOWNFIELD
LEFT SIDE – END OF RWY
PREV

RIGHT SIDE – BEFORE TD
RIGHT SIDE – AT TD
RIGHT SIDE – MIDFIELD
RIGHT SIDE – DOWNFIELD
RIGHT SIDE – END OF RWY
MENU

FIG. 48

CPDLC DU – Menu

BIRD REPORT

BEEP ON
SET PREFERRED RWY
SET PREFERRED RWY EXITS
SET PREFERRED ROUTING
SET LANGUAGE
PREV

BEEP OFF
VOICE COMMANDS
TRAIN VOICE COMMANDS
VOICE HELP
MAIN HELP

FIG. 49a
Pilot Runway Exit Request

5001 Start

5002 Receive exit request from CPDLC DU [FIG. 43]

5003 Get airline’s preferred routes

1005 Preferred taxiway routes database

5004 Decide on top 3 routes from the selected exit based on best rank and the airline preference

5005 Assign best route

5006 Send a “Routing selection” Control Message for CPDLC DU using process 3001 [FIG. 3]

5008 Assign route selected by Pilot

5007 Pilot selected another route?

YES

5009 End

NO

FIG. 50
Breaking Speeds And Runway Exits

5101 Start

5102 Get last 5 positions and timestamps of the aircraft

5103 Calculate rate of change in speed

5104 Calculate stopping location

5105 Get next exits

5106 Assign the next exit to the aircraft

5107 Send a "Exit selection" Control Message for CPDLC/ATMU using process 3001 [FIG. 3]

5108 Pilot selected another exit?

YES  5109 Assign exit selected by Pilot

NO  5110 End

FIG. 51
Aircraft Progress On A Taxiway

1003 Airport arrivals database

5201 Start

5202 Get assigned taxiway route

5203 Get aircraft location

5204 Retrieve time till complete

5205 End time – start time

5206 Position within timespan

5207 End

2308 Future aircraft positions for every minute until reached destination

FIG. 52
Request Release

5301 Start

5302 Get latest ATC responsible for the releasing takeoffs from the runway

5303 Get aircraft position

1001 Airport layout database

1010 Aircraft location database

5305 Wait 5 seconds

NO

5304 Takeoff roll can start within 2 minutes?

YES

5306 Send ICM a release request for Departure ATC

5308 ICM sounds a tone associated with a release request

5307 ICM displays release request to Departure ATC

5309 ATC released?

NO

5310 Wait 5 seconds

5311 ATC accepts release through the ICM

5312 ICM returns "release accepted"

5313 ICM sounds a tone associated with release acceptance

5314 End

FIG. 53
Cleared Junction

5401 Start

5402 Get aircraft location

5403 Get locations of junction APRS near aircraft

5404 Get last positions reported by any of the APRS for the aircraft in last 1 minute

5405 Sort the positions by timestamp (descending)

5406 Extract first two APRS reports

5407 APRS in same junction?

5411 Wait 5 seconds

5410 Aircraft did not pass junction

1010 Aircraft location database

1001 Airport layout database

5408 Aircraft cleared junction

5409 End

FIG. 54
Junction Congestions And Hotspot Levels

5501 Start

5502 Get future congestions and hotspots

5503 Get normal congestion levels

5504 Compare each of the junction congestion with the normal congestion level

5505 Discard any junctions with congestions lower than 20 percent of the normal level

5506 Sort the junctions by congestion levels

5507 Store all congested junctions for future use

5509 End

FIG. 55
Confirmation of Landing Gear from LGRC

5601 Start

5602 Get aircraft position, attitude and heading

5603 Aircraft passed LGRC lens start?

5604 Wait 100 milliseconds

5605 Import LGRC image

5606 Process image to focus on area of the aircraft nose and landing gear

5607 Correct angle of aircraft bottom

5608 Resize image to unified size

5610 Same as last image?

5612 Passed LGRC?

5611 Store latest update data for later comparison in buffer

5609 Last aircraft images

5614 Gear confirmed locked?

5615 Send a "unconfirmed gear" Control Message using process 3001 [FIG. 3]

5613 Compare images for gear movement

5616 Dispatch Emergency Personnel to location using process 3201 [FIG. 32]

5618 ICM sounds a tone associated with landing gear warning

5617 ICM displays a landing gear warning

5619 End

FIG. 56
Hold Short

START

5701
Get aircraft location

1010
Aircraft location
database

5403
Get locations of junction APRS near aircraft

1001
Airport
layout
database

5705
Wait 5 seconds

5704
Near a junction?

NO

5707
Is it a runway?

YES

5708
Send a Hold Short Command Message using 3001 [FIG. 3]

5706
Get other aircrafts in area

NO

5710
Other aircrafts near junction?

YES

5714
Send a Cross taxiway Command Message using 3001 [FIG. 3]

NO

5711
Has priority?

YES

5712
Send a Cross taxiway Command Message with “traffic will give way” using 3001 [FIG. 3]

5713
Generate a “cross taxiway, traffic will give way” voice ATC command over ATC radio frequency

5715
Generate a “cross taxiway” voice ATC command over ATC radio frequency

5716
End

FIG. 57
Runway Capacity Balancing

1001 Airport layout database

5801 Start

1002 Airport departures database

5802 Get all runways, even non-active

5803 Filter only active runways

1003 Airport arrivals database

5804 Get scheduled departures for next 60 minutes

5805 Get scheduled arrivals for next 30 minutes

5807 Calculate number of takeoffs and landings for all runways

5806 Sort by runway and expected time

5808 Calculate ratio of takeoffs in relation to landings for all runways

5809 Calculate each runway for scheduled operations vs. capacity

5810 Capacity exceeded?

YES

5811 More runways to check?

NO

5812 End

NO

5813 Check for best active runway to handle takeoff capacity overflow

5814 Any active runways available?

YES

5815 Divert to the other runway takeoffs that did not start taxiing yet

NO

5816 Can open any more runways?

YES

5817 Open another runway

NO

FIG. 58
Pilot Report - Breaking Action

5901 Start

5902 Get the aircraft type and runway used

5903 Decode CPDLC button (1L,2L,3L,4L,5L) [FIG. 45]

5904 Store the runway, time, aircraft type and breaking action

5905 End

FIG. 59

Pilot report - Runway Conditions

6001 Start

6002 Get the aircraft type and runway used

6003 Decode CPDLC button (1L,2L,3L,4L,5L) [FIG. 46]

6004 Store the runway, time and reported condition

6005 End

FIG. 60
Aircraft Takeover and Turning Autopilot On

6301 Start

6302 Get aircraft position, altitude, heading and route

1010 Aircraft Location Database

6303 Aircraft squawking distress?

YES

6306 Get authorization from secondary ATC facility

NO

6305 Auto.Takeover allowed?

YES

6307 Send a “Autopilot on” Control Message using process 3001 [FIG. 3]

NO

6304 Aircraft out of deviation limit?

NO

6309 ICM sounds a tone with takeover failure

6316 End

YES

6310 Send a “flight plan” Control Message using process 3001 [FIG. 3]

6312 Control Message success?

YES

6313 Wait 5-60 seconds depending on requested execution

NO

6314 Process required changes needed to heading or altitude or a complete plan

6315 Any changes to send to aircraft?

FIG. 63
Grounding All Aircrafts

6401
Start

6402
Get aircrafts in that can land at the airport

6403
Takeover all aircraft in area using process 6301 [FIG. 63]

6404
Create a list of all aircraft that takeover attempt failed

6405
ICM display ATC list of aircraft to handle manually

6406
ICM sounds a tone with takeover failure

6407
End

FIG. 64
### Used Reference codes

<table>
<thead>
<tr>
<th>CODE</th>
<th>REPRESENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Airfield lighting (AFL)</td>
</tr>
<tr>
<td>20</td>
<td>Tower facility</td>
</tr>
<tr>
<td>70</td>
<td>Gate or stand</td>
</tr>
<tr>
<td>100</td>
<td>Aircraft</td>
</tr>
<tr>
<td>110</td>
<td>Onboard CPDLC communication equipment</td>
</tr>
<tr>
<td>120</td>
<td>Onboard FANS - Future Air Navigation System</td>
</tr>
<tr>
<td>130</td>
<td>Onboard FMS - Flight Management System</td>
</tr>
<tr>
<td>140</td>
<td>Onboard CPDLCDU - The display Unit within the CPDLC</td>
</tr>
<tr>
<td>150</td>
<td>autopilot</td>
</tr>
<tr>
<td>160</td>
<td>Cockpit Computer System (CCS)</td>
</tr>
<tr>
<td>161</td>
<td>Dynamic Airport Map Software (DAMS)</td>
</tr>
<tr>
<td>300</td>
<td>Server - the computer running the AAATCS system and AMS[320]</td>
</tr>
<tr>
<td>310</td>
<td>ground-based communication equipment (GBCE)</td>
</tr>
<tr>
<td>311</td>
<td>Hand gesture sensing hardware (HAGSH)</td>
</tr>
<tr>
<td>320</td>
<td>Airport Management Software (AMS)</td>
</tr>
<tr>
<td>330</td>
<td>Interactive Controller Module (ICM)</td>
</tr>
<tr>
<td>331</td>
<td>Emergency Dispatch Module (EDM)</td>
</tr>
<tr>
<td>333</td>
<td>Airport Operations Center Module (AOCM)</td>
</tr>
<tr>
<td>334</td>
<td>Airport collaboration decision making (ACDM)</td>
</tr>
<tr>
<td>335</td>
<td>Automated handoff coordinator (HADOC) [335]</td>
</tr>
<tr>
<td>336</td>
<td>Air traffic management software (ATMS)</td>
</tr>
<tr>
<td>339</td>
<td>Airline Monitoring Module (SAMM)</td>
</tr>
<tr>
<td>340</td>
<td>Emergency Announcement System</td>
</tr>
<tr>
<td>350</td>
<td>Aircraft Position Reporting Devices (APRD) [351-354]</td>
</tr>
<tr>
<td>351</td>
<td>Radar</td>
</tr>
<tr>
<td>352</td>
<td>GPS</td>
</tr>
<tr>
<td>353</td>
<td>Aircraft Position Reporting Sensors (APRS)</td>
</tr>
<tr>
<td>354</td>
<td>Movement Detection Camera (MDC)</td>
</tr>
<tr>
<td>355</td>
<td>Landing Gear Reporting Camera (LGRC)</td>
</tr>
<tr>
<td>600</td>
<td>Wireless Communication Link for ACARS, ATN and FANS (WCL)</td>
</tr>
<tr>
<td>610</td>
<td>Air/Ground communication (AGC). Also related to AGC equipment</td>
</tr>
<tr>
<td>901</td>
<td>Control Message (CM)</td>
</tr>
<tr>
<td>902</td>
<td>Pilot Notification Tone (PNT)</td>
</tr>
</tbody>
</table>

**FIG. 65**
Merge and filter data for dynamic airport map

9601 Start

9602 Get aircraft location and nearby traffic

9603 Get nearby taxiways, runways and junctions

9604 Get list of available routes and taxiways

9605 is it a runway operation?

YES

9606 Get runway conditions and warnings from last operation

9607 Compute possible exits based on runway operation

NO

9608 Compute distances and times for next junction

9609 Compute area and boundary for display

9610 Apply operational notifications and alerts

9611 Calculate any operational timers

9612 Apply each item to own location on the map

9613 Apply menus depending on operation type

9614 Store possible click points for interaction

9615 Create an image of the overall map with information

9616 Send the aircraft the image as a Control Message

9617 End

FIG. 96
Marshalling breaks

9701 Start

9702 Get aircraft position, speed, heading and route

1010 Aircraft Location Database

9703 Wrong heading or the designated holding position?

9704 Notify pilot of Marshalling the breaks

9705 Send to aircraft Control Message for execution

9706 Notify Commanding ATC of breaks marshalling

9707 End NO YES

FIG. 97
Marshalling steering and engine power

9801 Start

9802 Get aircraft position, speed, heading and route

1010 Aircraft Location Database

9812 End

9803 Too slow or obstructing junction?

YES

9804 Calculate required changes in engines and direction

9805 Notify pilot of aircraft of Marshalling start

9806 Send to aircraft Control Message for execution

9807 Notify Commanding ATC of Marshalling start

NO

9808 Aircraft out of deviation limit?

9809 Stop marshalling

9810 Inform pilot marshalling was stopped

9811 Notify Commanding ATC Marshalling was stopped

FIG. 98
User Selection sent to AMS as Control Message

10101 Start
10102 Process command selected by pilot from touch
10103 Convert command to text
10104 Store text
10105 Convert text to Control Message format
10106 Encrypt the Control Message
10107 Send Control Message to AMS(320)
10108 AMS(320) Processes received message
10108 End

Pilot Voice recognition sent to AMS as Control Message

10201 Start
10202 Input pilot voice until stopped talking
10203 Process convert speech to text (STT)
10204 Store text
10205 Convert text to Control Message format
10206 Encrypt the Control Message
10207 Send Control Message to AMS(320)
10208 AMS(320) Processes received Control Message
10208 End
Recording onboard avionics and voice

10301 Start

10302 Input data changes from avionics interface, including data and all sounds in the cockpit

10303 Process convert sounds to data

10304 Store data

10305 Create a Control Message sent to be stored in a recording archive on a server

10306 Encrypt the Control Message

10307 Send Control Message to AMS[320]

10308 AMS [320] Processes received Control Message

10209 End

FIG. 103
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC:

IPC (2014.01) G08G 5/00, G01S 13/93

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols):

IPC (2014.01) G08G 5/00, G01S 13/93

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic database consulted during the international search (name of data base and, where practicable, search terms used):

Databases consulted: USPTO, THOMSON INNOVATION

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>Y</td>
<td>US 2012277986 A1 JUDD TOM D [US] 01 Nov 2012 (2012/1 1/01) paragraphs [0010], [0012], [0017], [0029], [0032]-[0034]</td>
<td>1-20</td>
</tr>
<tr>
<td>A</td>
<td>US 61753 14 B1 ROCKWELL COLLINS INC [US]; 16 Jan 2001 (2001/01/16) the whole document</td>
<td>1-20</td>
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<tr>
<td>A</td>
<td>US 2012306649 A1 RODGER BRUCE C [US]; 06 Dec 2012 (2012/12/06) the whole document</td>
<td>1-20</td>
</tr>
</tbody>
</table>

X See patent family annex.

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  "P" document referring to an oral disclosure, use, exhibition or other means to establish the publication date of a prior application or earlier priority (see specification)

Date of the actual completion of the international search: 26 Jun 2014

Date of mailing of the international search report: 26 Jun 2014

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