

Description

Airport guidance and control system, in particular an airport surface movement guidance and control system

5 The invention relates to an airport surface movement guidance and control system (SMGCS).

Airport surface movement guidance and control systems are known, for example, from the document BRITE II from N.V. ADB S.A., Zaventem, Brussels AP.01.810e, special issue for the Inter Airport 1995
10 Exhibition. The object of the invention is to refine the system described here, which operates using sensors arranged on the ground, in such a manner that it ensures optimization of the airport traffic, with an increase in the take-off and landing capacity of an airport in all
15 weather conditions, with the maximum possible safety. At the same time, flexible use of personnel in the tower should also be possible, in an advantageous manner.

The object is achieved in that the SMGCS operates with detection, integrated processing and graphical
20 display of the relevant, in particular the safety-relevant positions and movements of aircraft and, possibly, vehicles on airside (runway, taxiways, apron) and in the relevant airport airspace (CTR), by using at least one radar to discriminate between air movement and
25 stationary objects in a parked position, the relevant data being displayed in concentrated form, on the monitor of at least one controller in graphical form and/or letter or number form, in order that the operational management of the surface movement

can be prepared and carried out via said system. The system according to the invention, which covers in a particularly advantageous manner all movements which are necessary for controlling the surface traffic provides
5 the capability to create an integrated control and guidance system for airports, by means of which traffic optimization can be carried out with the maximum possible safety with regard to collisions on the ground and in the approach and departure area.

10 During flight, ground navigation aids protect aircraft against collisions. Non-visual and visual aids also assist with maintaining the predetermined glidepath in the aircraft's final approach. After touchdown, the aircraft moves on the riskiest part of its journey. As
15 has been shown, most accidents happen on the ground. The surface movement guidance and control system (SMGCS) according to the invention provides a critical further aid, allowing monitoring, guidance and control to be carried out without interruption. Such a system is also
20 called an advanced (A)SMGCS, until now an unfulfilled wish. This can be achieved for the first time according to the invention.

A refinement of the invention provides that the detection and operational management include vehicle
25 movements on airside, for example with the aid of transponder interrogations or squitters by transponders or via ID tags and wire-free communications means, which can also be used for transmitting instructions. This decisively increases the collision safety with respect to
30 ground traffic which, until now, has taken place largely in an uncontrolled manner, particularly in the apron area.

It is furthermore provided that the airborne movements in the approach and departure area be included in the detection and operational management. This results in optimization of surface movement planning, and, at the same time, in an increase in safety as a result of early identification of discrepancies between the actual state of the traffic and its planned state, for example if a taxiway is still occupied when it should already have been cleared.

10 A particular increase in safety is obtained by the use of both at least one primary radar and at least one secondary radar, the primary radar being used for location on airside, and the secondary radar preferably being used for identification in the approach and
15 departure area, using transponders. According to the invention, the identification on the ground is carried out by the approach radar (secondary radar) carrying out identification when traffic is moving and the docking guidance system carrying out the identification of
20 traffic which is taking off, and the identification being maintained by tracking the primary radar targets. In order to increase safety and reliability further, squitters from transponders in aircraft and, possibly, vehicles equipped with transponders are detected on the
25 ground, according to the invention, and the exact position is determined, with simultaneous identification, by multilateration of the signal arrival times. Redundant identification of aircraft, and possibly other vehicles as well, in the movement area of an airport is thus
30 possible at any time.

It is in this case provided that the system according to the invention has a taxiing movement planning component by means of which it is possible

for the controller to propose taxi routes and for these routes to be checked automatically for freedom from collisions. The planning component and the check of freedom from collisions are carried out by permanently
5 installed software, into which the appropriate safety features are input. This also ensures compliance with the minimum separations, depending on the various weather conditions. This planning software also includes intermediate stop positions for the aircraft, which guarantee
10 collision-free movement in the apron area as well. The plans are advantageously based on the flight plans. At large airports, the take-off and landing movements do not actually take place spontaneously but are planned in accordance with flight plans, as is the gate occupancy.

15 It is provided for the necessary displays to be produced on a monitor for the controller via a video subsystem (processing) which is known per se in the airport surface movement guidance and control system. Such radar video subsystems are available, for example,
20 from a company HITT, one example being the advertisement in the journal "Jane's Airport Review, Sept. 1995, Volume 7, Issue 7, page 46". Such a system is not the subject matter of the invention.

A display corresponding to the details of the
25 BRITE II system is produced on the radar video, with greater data concentration and more detailed statements than would result from the combination of the known BRITE II system with the known radar video from the company HITT. This is also a not insignificant object of the
30 invention.

It is advantageously provided that the displays on the monitor, for example the actual radar video or a synthetic radar display and/or a synthetically formed display of the traffic movements at the airport, can be concentrated on a monitor using windows with status displays, handover lines and acknowledgement lines etc., as well as with the switching states of the taxiway lighting sections, the stop bars etc. This concentration is carried out as a function of the respective amount of traffic at the airport such that, for example, only one controller station need be occupied at night, while further controller stations are formed in the morning, as the amount of traffic increases. The responsibility for the individual controllers in the tower is then split appropriately.

The handover of responsibility is advantageously carried out after a handover acknowledgement in the window display on the monitor or on auxiliary monitors, in order that the workstations can be allocated safely. The sequences in this case advantageously correspond to the sequences as are known in systems for stripless organization of a tower. An example is shown in the document TECOS Terminal Coordination System, Ident. No. 02963.0 from Siemens AG dated 1996.

A particularly advantageous implementation of the sequences indicated above is possible if a large flat screen is used to display the individual windows, the radar video etc., in particular designed as a touch-screen. In the case of such a touchscreen, not only is it possible to carry out a switching operation by touching the respective points, for example the stop bars or taxiway sections on the synthetic display which is formed,

but this can also be done by clicking with a mouse or by operating switching points at the edge of the monitor. It is thus possible to concentrate in an advantageous manner all the switching points, which until now have been in
5 separate panels, so-called keyboards, in the visual range of the controller. The safety of operation is correspondingly increased with the option for direct control and confirmation of the switching processes carried out.

For the necessary data concentration, it is
10 provided that all the data are first of all digitized, that is to say including the radar data which are present in analogue form. Plot extraction is advantageously particularly helpful in this context, with the assistance of data fusion and the inclusion of sensor correlation.
15 All data are changed to a standard format and are then output to the radar video or a complete synthetic display.

In order to increase the planning safety and to take account of emergencies, it is provided that the
20 system is supplied with data relating to aircraft movements in the airspace further away, possibly with approach and departure positions, positions on the taxiway and, possibly, in the parking area being determined by GPS, in particular differential GPS. The use of
25 GPS in this context increases safety since additional position information is thus available. However, because of the uncertainty of the GPS function, particularly in the terminal area, this configuration is envisaged only for increasing safety, that is to say as an additional
30 function. The actual management of the traffic is carried out using reliable radar data and other ground sensors as well as by

visual inspection by the controllers. These sensors may also be optical sensors, for example for the docking area, in this case in the form of lasers or raster cameras. Further refinements of the system components can
5 be found in the dependent claims 18 to 21.

With respect to the docking system, the safety is advantageously increased if the position data supplied from the docking system are introduced into the data fusion and sensor correlation, and vice versa. If this is
10 done taking account of the parking position plans, that is to say these are also included in the surface traffic plans, safety is increased further.

The invention will be explained in more detail with reference to drawings from which, in the same way as
15 from the subclaims, further details which are also essential to the invention can be taken. In detail:

- FIG 1 shows a schematic illustration of SMGCS components in a version according to the prior art,
FIG 2 shows a schematic illustration which shows the
20 interaction of the individual SMGCS components,
FIG 3 shows the reproduction of an actual radar video,
FIG 4 shows the reproduction of a synthetic display with window displays, and
FIG 5 shows an overview of the essential information
25 transmitted.

In FIG 1, which is taken from the already mentioned document AP.01.810e, 1 designates the airport LAN. 2 designates the monitor of a controller's station and 3 the monitor, while 4 is the printer for the service and maintenance computer. The monitor 2 is designed either using conventional monitor technology or as a flat panel screen, in particular with a touchscreen configuration. 5 designates PLCs and 6 the BRITE-PC which, according to the invention, is integrated in the ATC tower monitor. FIG 1 actually shows the prior art. The software which is required to operate the BRITE II system is located in the BRITE Master 8 and produces the desired switching states in the BRITE units 9. The BRITE units are connected to sensors 10, which may be configured relatively as required. As illustrated, the BRITE units are located in a series circuit in order to ensure that all units have the same brightness. In the prior art illustrated, no data link is provided to the airport radar systems.

In contrast to this, the SMGCS design according to the invention has an integrated controller workstation, advantageously based on X-Windows and an open architecture. In this case, a synthetic display is produced from the raw video (actual display video) together with maps, object data, conflict messages, flight plan data, stop bar data and lighting data.

In the course of integration, a sensor system is provided which represents a combination of various sensors, primarily various radar systems. The sensor data are

fused in order to ensure smooth monitoring.

Data processing is carried out via multisensor tracking and labelling with the sensor data being correlated with flight plan data, lighting data and docking/
5 gate-occupancy data. The airport traffic is then controlled on this basis.

In FIG 2, 11 designates a block containing sensor data for monitoring, 12 designates the processes which are used for monitoring and 13 represents the reference
10 point for the controller, the pilot etc. 14 designates a high-speed data network (Airport LAN) which is designed as a fault-free, fail-safe system. The information from block 15, that is to say from peripheral services, also flows into this system. The airport personnel carry out
15 the monitoring operations which are illustrated in block 16, as well as the inputs which are required for this purpose. Finally, block 17 shows the essential system components which are used.

FIG 3, which is self-explanatory, shows an actual
20 radar video. This forms the basis of the sensor system which is used. The sensor system transmits data about the position and, possibly, about the speed, direction and identity number of all aircraft and vehicles. In addition, there is also information about stationary objects
25 and their relative position to the indicated positions of aircraft and vehicles. The radar video is supplemented by the details from stationary sensors, particularly important for areas with radar shadowing.

The combination of all the abovementioned sensors produces complete information about the airport traffic.

In FIG 4, 20, for example, designates a runway and 21 taxiways. Stop bars 22 or the like are located on the taxiways, as well as other lighting and information devices which are not shown in more detail for reasons of simplicity. FIG 4 shows an advanced synthetic display, that is to say to this extent also the prior art. The new synthetic display is designed in a more detailed manner according to the invention. 23 designates a window display of the flight plan, and 24, 25 and 26 as well as 27 designate further flight plan and assignment windows. It is self-evident that these and further details can be displayed in an adequate size and in a clear arrangement on a large flat screen. A flat screen is recommended in order to achieve, for example, a low physical height and to enable the installation of other systems and/or to create space for other systems.

In FIG 5, the essential details which the synthetic display contains are listed in 30. 31 shows the two types of sensors, which may operate on a very different basis. Most important are the sensors which operate cooperatively and at the same time verify the aircraft identification. 32 shows the basics of the movement guidance and control system, and 33 the auxiliary functions which are important in particular in the event of special occurrences. 34 shows the component by means of which the actual control of the aircraft on the runway and the taxiways as well as in the apron area is carried out, and 36 shows the docking automation, which may be carried out with widely different sensors

(lasers, raster cameras, microwave receivers, D-GPS etc.). Finally, 35 indicates the integration of the widely different data which flow together in the system.

It is self-evident that the system according to
5 the invention is used even if all the individual components described here are not integrated in the system but are operated as stand-alone systems, or if individual components, such as automatic docking systems, are entirely dispensed with, for example at relatively small
10 airports with only a few parking positions. The basis of the integrated handling of the essential data, which provide information about the positions and movements of the aircraft and possibly vehicles, on one workstation, with the option for splitting the controlling tasks,
15 remains as the solution according to the invention.



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Patent Claims

1. Airport surface movement guidance and control system (SMGCS) with detection, integrated processing and graphical display of the relevant, in particular the safety-relevant positions and movements of aircraft and, possibly, vehicles on airside (runway, taxiways, apron) and in the relevant airport airspace (CTR), by using at least one radar to discriminate between air movement and stationary objects in a parked position, the relevant data being displayed after data concentration, on a monitor of at least one controller in graphical form and/or letter or number form, in order that the operational management of the surface movement can be prepared and carried out via said system.
2. Airport surface movement guidance and control system according to Claim 1, characterized in that the detection and operational management include vehicle movements on airside, for example with the aid of transponder interrogations or squitters by transponders, via ID tags and wire-free communications means, which can also be used for transmitting instructions.
3. Airport surface movement guidance and control system according to Claim 1 or 2, characterized in that the airborne movements in the approach and departure area are included in the detection and operational management.

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4. Airport surface movement guidance and control system according to Claim 1, 2 or 3, characterized in that said system has a primary and/or secondary radar, the primary radar being used for location on airside, and
5 the secondary radar preferably being used for identification in the approach and departure area, using transponders.

5. Airport surface movement guidance and control system according to one or more of the preceding claims,
10 characterized in that said system has a multilateration system (e.g. CAPTS) which uses multilateration of the signal arrival times to determine exact position with simultaneous identification using transponder squitters.

6. Airport surface movement guidance and control
15 system according to Claim 4 or 5, characterized in that, on detection by the primary radar, the identification of the detected aircraft is carried out with the aid of data sources, and is displayed while being retained in the system.

20 7. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that said system has a taxiing movement planning component, by means of which, taking account of the respective landing direction, collision-free taxiing
25 traffic and other surface movement is planned, taking account of the necessary safety separations, as a function of the weather category (CATI-III).



8. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that the airport traffic routes, the aircraft and vehicle positions and, possibly, speeds, as well as taxiing directions can be displayed in said system via a radar video which is known per se or via a synthetic display.

9. Airport surface movement guidance and control system according to Claim 8, characterized in that, in particular, the approach, - the take-off and landing runway - , apron and taxiway as well as parking position signal devices are detected, and their signal state is displayed, on the radio video or on the synthetic display.

10. Airport surface movement guidance and control system according to Claim 8 or 9, characterized in that the displays can be concentrated on a monitor.

11. Airport surface movement guidance and control system according to Claim 10, characterized in that the monitor is also designed to display windows with status displays, handover displays, particularly in line form and acknowledgement lines, etc.

12. Airport surface movement guidance and control system according to Claim 7, 8, 9, 10 or 11, characterized in that the taxiway lighting sections, the stop bars and all the other signalling devices which are necessary to control surface movement, and their switching state can be displayed, in particular linked



to other safety-relevant information, in said system.

13. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that the data which are detected in the system can be split between one or more controller locations and can be processed on the basis of the respective responsibility, depending on the respective amount of traffic at the airport.

14. Airport surface movement guidance and control system according to Claim 12 or 13, characterized in that the handover of responsibility takes place after a handover acknowledgement in window displays on the monitor or on auxiliary monitors.

15. Airport surface movement guidance and control system according to Claim 9, 10, 11, 13 or 14, characterized in that the handover of responsibility takes place from the approach area to the runway control area via the taxiway control area to the apron control area and, in the reverse sequence for departure, by regrouping electronic flight strips (stripless) and designating the respective responsibility in monitor windows, possibly in conjunction with the radar video or a synthetic display.

16. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that the radar data, in particular with plot-extraction, are processed, together with the status of the taxiway,



landing and take-off runway lights as well as other sensor components (or else transponders), possibly with the aid of data fusion and sensor correlation, to produce a standard format, in particular being completely digitized, and are then output to the radar video or are composed to form a complete synthetic display and/or are output to other monitor displays.

17. Airport surface movement guidance and control system according to one of Claims 9, 10, 11, 12, 13, 14, 15 or 16, characterized in that the radar video, possibly windows with status displays, handover lines and acknowledgement lines etc., are displayed on a flat screen having a screen diagonal of more than 19 inches (flat panel) which is designed, in particular, as a touchscreen with switching elements for airport lighting, for voice communication etc.

18. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that said system is supplied with data relating to aircraft movements in the airspace further away, possibly with approach and departure positions, positions on the taxiway and, possibly, in the parking area being determined by GPS, in particular differential GPS.

19. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that said system has a maintenance computer with a monitor on which the necessary maintenance and



repair tasks, possibly as well as light failures, can be displayed.

20. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that the lights of the airport lighting system are designed such that they can be addressed individually, and, for this purpose, are equipped with EPROMs, in particular EEPROMs/flash PROMs.

21. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that said system has an airport data transmission system which operates using glass-fiber transmission technology, coaxial cables and/or twisted pair cables, in particular of a redundant design.

22. Airport surface movement guidance and control system according to one or more of the preceding claims, characterized in that said system has an automatic docking system which operates in particular with optical detection, for example via raster cameras or laser ranging and detection, for determining the aircraft position, possibly with the assistance of a transponder identification system for the optically detected aircraft.

23. Airport surface movement guidance and control system according to Claim 15, 16, 17, 18, 19, 21, 22 or 23, characterized in that the position data supplied from the docking system are introduced into the data fusion and sensor correlation, and vice versa.



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24. Airport surface movement guidance and control system [lacuna] Claim 21 or 22, characterized in that the selection, occupancy and status messages for parking positions are produced on the basis of flight plans, and
5 are displayed on the monitors.