PSD
Preliminary System Description

For Cortex Advanced

Revision 1.0

1 Revision

REV	DATE	DESCRIPTION	RESPONSIBLE
1.0	June 2024	First issue	LL/GON

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3 Glossary

Abbreviation	Description
ADB SAFEGATE	ADB Safegate
AGL	Airfield Ground Lighting
AGL – function	A group of AGL Lighting circuits that are always controlled simultaneously.
ALCMS	Airfield Lighting Control and Monitoring System
ATC	Air Traffic Control (tower).
Auxiliaries	All AGL Devices excepting those belonging to the series circuits.
AUX	Auxiliary
CCR	Constant Current Regulator.
Com. Tr.	Communication Transformer
CSM	Circuit Selector Module.
DTN	Background Visibility selection (for Day-Twilight-Night)
DOV	Detailed Object View of an AGL equipment. This view regroups the status, alarm messages and individual control of this particular equipment.
EFD	Earth Fault Detection
Ethernet	Network protocol developed jointly by Xerox, Intel and Digital Equipment Corporation. Ethernet networks use CSMA/CD and run over a variety of cable types at 10 Mbps (megabits per second), 100 Mbps or 1Gbps (Gigabit per second).
FO-SC	Fibre Optic with SC standard connectors
GUI	Graphical User Interface
HMI	Human/Machine Interface
J-Bus	Field bus subset of MODBUS, which allows interfacing the remote control and monitoring system with each current regulator.
LED	Light Emitting Diode
MCR	Microprocessor Controlled Constant Current Regulator
MW	Multiwire
NCU	Network Concentrator Unit – IO and ILCMS PC from ADB-Safegate
Node	Single location where ALCMS components are installed (e.g.: ATC, Substation, Maintenance center).
OFDM	Orthogonal frequency-division multiplexing
OPC	Open Circuit Alarm
OVC	Overcurrent Alarm
PLC	Programmable Logic Controller
RVR	Runway Visual Range (Visibility measurement)
SAT	Site Acceptance Test.
SUB	AGL Substation
TCP/IP	Transmission Control Protocol Internetwork Protocol
Transf.	Transformer
UPS	Uninterruptible Power Supply
UTP	Unshielded Twisted Pair cable used for Ethernet protocol between computers (Short distance).

4 Introduction

4.1 Objective of this document

This document provides a Technical Description of ADB SAFEGATE's Cortex Advanced Airfield Lighting Control and Monitoring System (ALCMS).

This document is, for the purpose of this submission, to be considered as a clarification outline paper to identify and assess the development of the design definition requirements.

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4.4 About ADB SAFEGATE

Being market leader in the field of Airfield Ground Lighting, ADB SAFEGATE provides products, airside solutions and services for airports worldwide. Operating in over 250 countries, ADB SAFEGATE strives to continue to set the standard in innovation and technology, while offering optimal solutions for ground traffic management at airports, through visual aids. By doing so, we support airports around the world in enhancing their airside safety, efficiency, availability and maintainability.

Quality of our products, solutions and services is of outmost importance – seeing the environment that they operate in, and the operational requirements on safety and reliability that they must sustain. Therefore high levels of quality management during design, engineering, manufacturing and shipping processes are continuously maintained, in accordance with our ISO 9001 procedures.

4.5 Applicable Documents

The most recent revision of the following documents form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of the program contractual documents shall be considered the superseding requirement followed by the contents of this system specification.

Reference	Title
[ICAO]	ICAO Annex 14, Volume 1 (Aerodromes)
[ICAO]	ICAO Manual of Surface Movement Guidance and Control System, Doc 9476-AN/927
[ICAO]	ICAO European Manual on Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Doc 9830 – AN/452 first edition 2004.
[Eurocontrol]	EUROCONTROL-SPEC-171, EUROCONTROL Specification for Advanced-Surface Movement Guidance and Control System (A-SMGCS) Services
[ISO 9001]	Quality systems – Model for quality assurance in design, development, production, installation and servicing

5 Our ALCMS philosophy

5.1 General purpose of an ALCMS

The primary goal of an Airfield Ground Lighting Control & Monitoring System (ALCMS) is to provide control and monitoring functionalities for visual aids to enhance safety, efficiency, maintainability, and reliability of the airside operations.

Practically, this means that the ALCMS is used to control and monitor all Airfield Ground Lighting (AGL) equipment installed on the airfield, and as such supports the efficient and safe maneuvering of all ground traffic at an airfield. This is achieved by using a series of Computers and/or Programmable Logical Controllers (PLCs) that will transfer the ATC operator's commands to the various devices in the field; monitor their status and provide the appropriate feedback to the operator and maintenance staff.

The ALCMS is part of a modular and scalable system platform – for both hardware and software. The purpose of this modular approach is to be capable of growing with the airport needs; as and when changes are required in the future, options may be added to extend the functionality.

5.2 Safety

Safety is of crucial importance in airside operations. This is also valid for any ALCMS being implemented at a live airport. Safety requirements are to be taken into consideration in the ALCMS design, development, installation, commissioning and training that comes along.

The general guidelines used are provided here:

- Competent development management: the ALCMS concept is based on ADB SAFEGATE many years of experience in AGL products and systems development. Being active member of several international regulatory organizations that define new standards for the AGL industry, ADB SAFEGATE possesses long experience and thorough understanding of airside processes, their impact on AGL requirements, and the relevance of safety to that. This is reflected in safety being an integral part of the design process of ADB SAFEGATE products and standards. Defining the concept of safety in individual designs, considering relevant fail-safe modes of operation, supporting the development of safety cases are important instruments in this respect.

- Selection of Hardware components and architecture design, in order to safeguard the availability of the ALCMS, the proposed architecture considers using high available components, typically industrial equipment, for the crucial parts of the system. Depending the level of availability required to ensure safe operations at the airport, the ALCMS design may further consider redundancy for critical ALCMS components, ensuring the failure of one component will not compromise the operations.

- Intuitive design of user interfaces, to have systems which are easily comprehensives by the end users whitout requiring extensive trainings is key to safety. The ADB SAFEGATE delivered systems are developped along the years using the feedbacks received by the wide range of Air Traffic Controllers and Maintenance team users helping us making the ALCMS easy to handle by the airports.

- Finally, another safety-supporting functionality is the use of logging mechanisms in the ALCMS. This covers both the logging of operational events in the ALCMS, as well as a detailed logging of a range of technical parameters.

5.3 Design Philosophy

The ADB SAFEGATE proposed solution for the new Airfield Ground Lighting Control & Monitoring System (ALCMS) has been designed to ensure a safe and user friendly ATC operators user interface fully in accordance with ICAO regulations and recommendations.

The design for the ALCMS, gives due consideration to the relevant internationally accepted standards, ICAO Annexe 14, and also Aerodrome Design Manual Part-4 and Part-5.

During the design of the ALCMS particular attention has been paid to the following requirements:

- Reliability. To enhance reliability, the system shall as much as possible consist of proven modules, individually well designed, implemented and tested.
- Flexibility. To enhance flexibility and adapt to customers' requirements the system shall be modular and each module shall be configurable without "coding".
- Extensibility. The system shall be future proof; thus, the platform shall work with internal data layers that can cope with more data and where new modules can easily be added and exchange data for functionality to come.
- Availability. The software shall adapt redundant solutions, and work together with high end hardware to ensure 99.999% calculated availability.
- Maintainability – System shall adapt use of Line Replaceable Units, Self diagnostic, Self-healing, and easy deployment support.
- Long lifecycles – system modules shall be regularly updated, and a latest version shall always be available using continuous delivery. Backwards compatibility shall always be possible. The tools used shall be updated and supported (Microsoft visual studio used). System shall support latest hardware as soon as possible.
- User-interface customizations. HMI shall be easy to upgrade/change (thin HMI layer). It shall allow multiple new technologies or operational concepts to be adapted.
- Cyber secured . System shall prevent unauthenticated access at computers and interception of data on the communication layer. Solution shall allow easy deployment of patch.
- Response time. System shall have quick communicatin with responsetimes as low as possible
- Scalability. System shall be able to scale to very bit airport configurations, many user clients etc. without creating any communication bottlenecks.

6 System Architecture

6.1 System Topology

The proposed architecture of the complete ALCMS can be divided into Four levels:

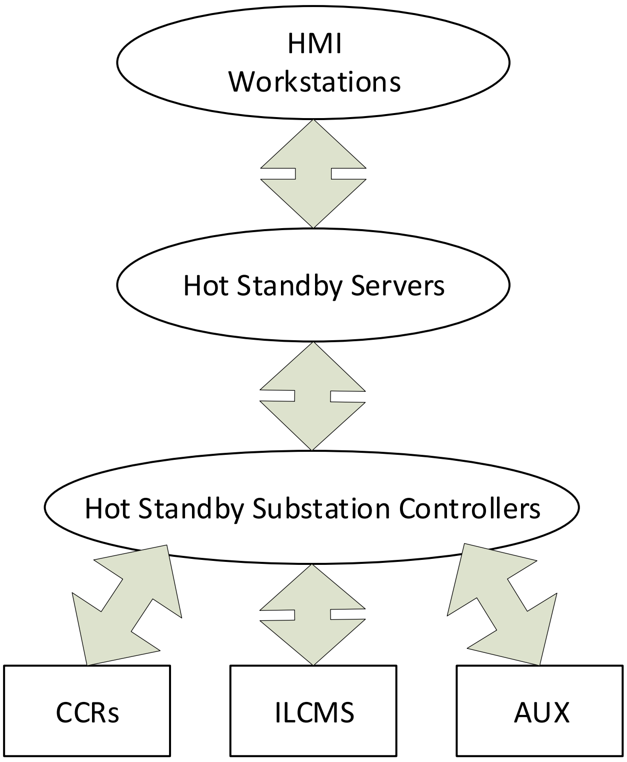
- Control level: Human-Machine Interface (HMI) computers for ATC operators and maintenance staff: the top-level HMIs for command and visualization provides control and monitoring functionality to the ATC operators and detailed graphical feedback of the airport's AGL equipment to the maintenance staff. Using multiple HMI computers provides a flexible standby solution.

- Consolidation level: Centralization computers with a server-role working in hot standby redundancy will be the key element of the proposed ALCMS, they will interpret the orders given by the Control Level and transfer to the execution level and opposite.

- Execution level: Redundant substation computers to which the field equipment is connected. It is this level that will execute the commands from the control level and pass it through to the field equipment, via the dedicated field busses/protocols and interpret feedback received.

- Communication level: Dedicated communication network comprising redundant units between all locations, to connect computers and other network enabled equipment.

At each of these levels, dedicated components are used to perform the level-specific tasks and achieve the required degree of performance.



6.1.1 Workstations (Control level)

All computers delivered in the scope of the project will be professional desktop PCs. Commercially-of-the-shelf (COTS) components are used to ensure availability of spare parts and/or compatibility with future generations of hardware.

The workstations are equipped either with touch screen monitor for ATC or with a standard monitor for Maintenance.

To ensure the availability of the System for ATC, in case of failure of the Main Workstation, any other workstations can act with the same functionalities to continue operation.

6.1.2 Servers (Consolidation level)

To guarantee the availability of the system, all computers with server-role delivered in the scope of the project will be high performance units acting in redundancy.

The servers are equipped with a Keyboard Video Mouse tray allowing for interaction.

6.1.3 Substation cabinets (Execution level)

The control equipment installed in the substation is mounted in an industrial grade cabinet. The cabinet's dimensions and internal layout of equipment are adapted to provide an optimum match for the airport's requirements, also taking into account future upgrade possibilities.

The cabinet equipment consists of a combination of the following components:

- Industrial grade Substation computers equipped with serial/Ethernet interfaces for CCRs, ILCMS, auxiliary units and Sensor communication.
- Siemens Simatic PLCs with necessary I/Os for controlling the digital equipment or interface cards for specialized field busses.
- Fully pre-installed and labeled interface relays for Multiwire controlled equipment, providing easy connection for on-site installation.
- Industrial grade networking equipment for Local Area Network within the substation.

6.1.4 Networking (Communication level)

The different locations within the scope of the ALCMS (typically: ATC tower, AGL substations, and maintenance facilities) should always be interconnected by means of a redundant communication network either dedicated or protected from other Airport systems using VLANs.

6.1.5 ALCMS application (software)

The ALCMS application software is fully developed by ADB SAFEGATE to meet the specific business requirements behind the design philosophy.

The applications adapt a micro-service architecture to allow maximum flexibility for deployments, maximum maintainability of the software which can be step wised upgraded and tested, scalability to allow deploying system configuration from single computers up to very large systems.

All applications interact using high performing event-driven inter-communication data layers, which also allow new applications and interfaces to be added for customer specific logic or interfaces.

All applications run on Microsoft Windows which hosts an environment that ensure a long lifecycle for the software even in case of new releases of the Operating System.

The software is developed and maintained using latest technologies via Microsoft Development tools, and tools for Web Development.

6.1.6 Uninterruptible Power Supply (UPS)

All the control and monitoring equipment can be secured with UPS units. The status of each UPS can be monitored on the system's HMIs. Alarms and warnings will be issued to the operators when the system is running on UPS or when the batteries get empty.

The standard backup duration of the UPS (20 minutes) can be upgraded with battery extension packs if required.

6.1.7 Individual Lamp Control and Monitoring System

The ILCMS has been developed to combine both the need of simple control and monitor airfield lamps and devices with fast and predictable response times and the demand to reduce installation and commissioning time and allow the customer to enhance safety and performance of the entire airport.

The ILCMS system is designed to meet the latest ICAO standards. The system complies with CAT I/II/III ICAO lamp supervision requirements and supports A-SMGCS for enhanced aircraft guidance in all weather conditions to prevent aircraft collision during taxiing and runway incursion.

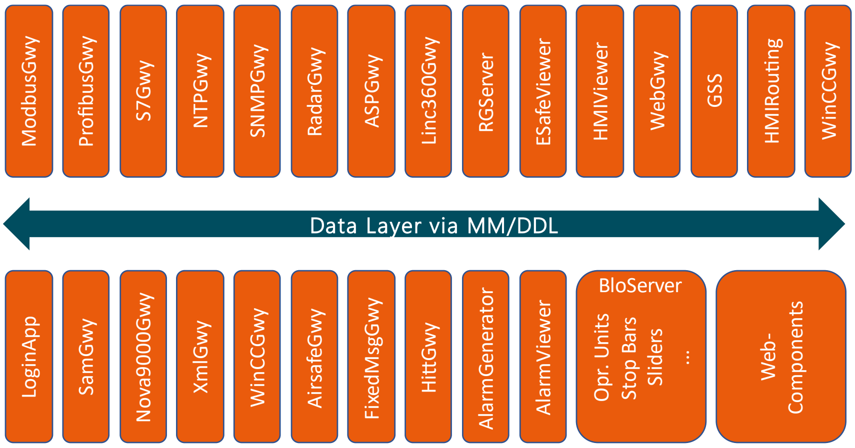
The ILCMS system uses the serial circuit powering for the fixtures as the communication carrier, requiring no extra cable. The ILCMS remotes or Intelligent light are addressable units having a unique address allowing the control of the connected fixtures. This control can be done individually or in a group. Each ILCMS remote reports back its status as well as the status of the connected fixtures.

The ILCMS system, consisting of the main components ILCMS Master, ILCMS Remotes or Intelligent light and an ILCMS control process running on an ILCMS server. ILCMS Remotes are installed between series transformer and the light fixture, the ILCMS Master is located near to the CCR and directly connected to the CCR out power ensuring the power line communication of his dedicated circuit. The ILCMS server is installed within the ALCMS enclosure of which it's from part of ensuring the control and monitoring of lights in groups or individual.

6.2 Software architecture

6.2.1 Microservice Architecture and deployments

The system consists of multiple applications that each handle a specific task in the system. This allows a unique separation in the system functions and at the same time ensure full encapsulation of functionality, which is a huge benefit for the Continuous Development strategy adopted by ADB SAFEGATE to timely meet our customer's needs.



To deploy a system comprising of several computers, then for each computer the relevant set of application will be started based on the role the computer has in the system. Typical the applications will be distributed on at least 3 types of computers:

- User Interface Computers (Computers for ATC or Maintenance Users)
- Business Layer Computers (Server role)
- Interface computers (Typical Substation controllers, or computers for 3rd party interfaces).

The roles can also be combined. E.g. a substation computer, can also run applications for User Interfaces, or part of the Server role can be placed at the HMI computers in Tower, or where all equipment has ethernet interfaces the interface functionality can run on the business layer computers, thus saving interface computers.

The flexible setup also allows to deploy smaller training or test systems, which then typical will run with simulation of the external equipment.

6.2.2 Secured application environment

The Cortex Advanced ALCMS include functionality to protect the system against intruders whether direct from the ALCMS computers user interface or from the network.

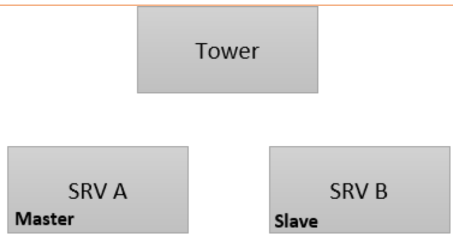
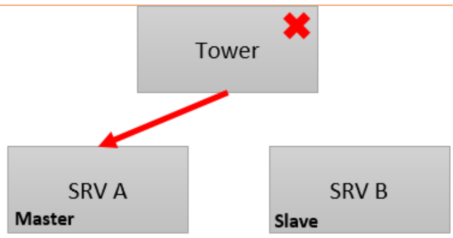
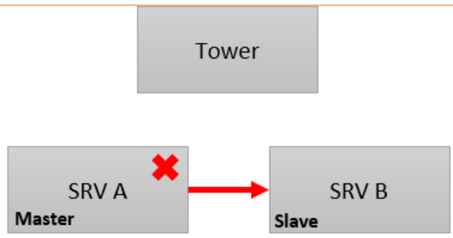
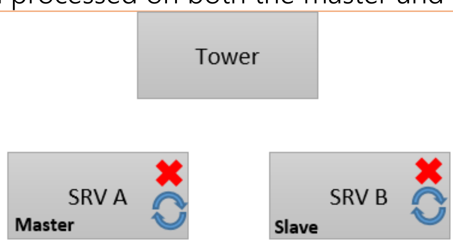
Most of the ALCMS services are not intended for the normal users (non-administrator). They are intended to run in the background without any User Interface. Such applications can be installed and run as a Windows Services. This allow the services to run as soon as the computer starts up without any users being logged into Windows. Even when a normal user does login, it still prevents none administrator users from stopping or tamper with the execution.

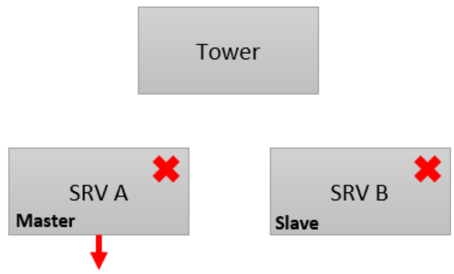
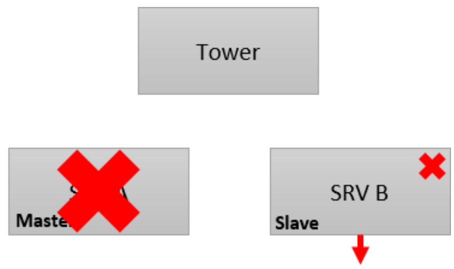
If the computers are joined to an Active Directory, further intrusions protection is possible. Here, the server services can be configured to require encrypted and authenticated connections from client services and applications running on Domain Joined Computers or by Domain Users configured with ALCMS role. This ensure that users not authenticated by the AD, cannot penetrate the ALCMS system whether from the ALCMS computers or by computers/devices attached to the ALCMS networks.

6.2.3 Application redundancy

The ALCMS also use redundancy at the application level. This means there is a redundant computer running the same applications on hot standby all the time for each location.

To put this into perspective, the following diagrams will show how the application redundancy works. This specific example shows how the redundancy on the computers with server-role works.

Application Redundancy
We have two redundant computers acting as servers, one of which is master at a tower location.

The HMI computer at tower increases the intensity of some equipment for which a message is sent out to the master server.

As soon as SRV A receives the message, it sends it further to SRV B for redundancy purposes. The idea is that both servers will then have the same input to process in case of failure on either of them.

The message is then processed on both the master and the slave server.

When the master finishes processing the message, depending on the message it either sends it back to the tower or further down to the

Application Redundancy
equipment. Either way, SRV A being the master, it will send something out whereas SRV B will not send anything out.

Unless there is a failure on the master server, the slave will never send anything out. It will keep the processed result in case the master fails. If a failure occurs on the master server, the slave server will immediately kick in and send the message further.


6.2.4 ALCMS Redundancy logic

The by ADB SAFEGATE chosen solution implements different redundancy levels to avoid system downtime; this is done by multiplying all the processes.

- On the Workstation level:
  The proposed ALCMS is composed of multiple workstations. Each workstation has the same capabilities and can be used to replace a defective one.

  Besides, each workstation connects both servers. In case of failure of one server, the workstation automatically addresses the backup server to continue operation.

- On the Server level:
  There will minimum be 2 servers, they are completely redundant, they update themselves with the information of the Master, in order to ensure the instantaneous switch over, in case of failure of the primary one.

- On the Substation Level
  There will be 2 substation controller computers where physically possible. Each controller can maintain the communication to the CCRs, Auxiliaries and Sensors, which might be interfaced via PLCs. If the currently active controller fails for whatever reason, the alternate controller will take over the operation, with no operational consequences.

6.3 Hardware Architecture

This chapter will describe the ALCMS hardware architecture, the components used, the AGL equipment which will be controlled, their interface, the network and the interface with other systems.

6.3.1 System architecture

The main characteristics of the ALCMS are:

- Multiple HMI workstations in the ATC Tower with a customized user interface to control and monitor the AGL equipment.
- Multiple HMI workstation in the Maintenance Room and/or Substations with a customized user interface to control and monitor the AGL equipment and specifically designed to support the maintenance activities of the airport.
- Two computers with server-role, installed in the ATC Technical room or in any other location defined during the project. These computers also host interfaces to other airport systems being interfaced.
- Control and monitoring of the AGL equipment is realized by the redundant substation controller computers installed in each Substation ALCMS cabinet.
- Two independent network switches in each location, together forming two ALCMS fiber network rings. The network rings are preferable dedicated the ALCMS or if shared with other airport systems the ALCMS network traffic shall be segregated for cyber security reasons.
- A LINC360 Solution providing individual light control and monitoring to the ALCMS and composed by several LINC360 controllers installed in each Substation, these are interconnected through a redundant fiber optic network switch installed in the Substation cabinets.
- A set of ILCMS Servers will be used as gateway between the ALCMS and LINC360 Solution installed in the ILCMS Cabinets.

6.3.2 System components

6.3.2.1 *User interface (HMI) Workstations*

The HMI workstations for ATC use will typical be installed at the upper Tower Equipment Room. From here KVM extenders will be used to connect the Monitors, the Sound devices and any Keyboard and Mouse installed in the Tower Visual Control Room.
Alternatively the workstations can be installed in the Console in Tower VCR, in which case the workstation models will be selected for low noise and low heat emissions.

The HMI workstations for Maintenance use will typical be installed under the desks where they are to be used together with sound, keyboard, and mouse.

For ATC use the monitors will be 24" touch monitors. Here, the keyboard and mouse are typical only used during software installation and testing by maintenance personnel. The Maintenance working positions are equipped with a normal monitor and keyboard and mouse will be used as input devices.

Each HMI working position provides the interface between the users and the System and is composed by:

- One Industrial 19" Computer Siemens IPC547 family
  - Intel i7 processor
  - 16Gb RAM
  - 500Gb HDD
  - 2 Network interfaces
  - Windows 11
- One 22" Dell Touchscreen monitor
- For ATC, a set of KVM extenders G&D DP-Vision-IP-Fiber ensuring the extension of the monitor, keyboard, mouse and touch functionalities of the ATC HMI.

6.3.2.2 *ALCMS and ILCMS Servers*

For each, the ALCMS and ILCMS solutions a set of Servers will be used to provide the interface between the HMIs and the equipment controllers, storing the database and logs.

These Servers will be of industrial type, rack mounted and installed in cabinets, sharing a KVM tray monitor in the cabinet where installed allowing for local management.

The main specification of the Servers will be:

- Industrial 19" Computer Siemens IPC547 family
  - Intel i7 processor
  - 32Gb RAM
  - RAID1 hot swappable 500Gb HDD
  - Dual power supply
  - Multiple Network interfaces to allow the integration of the several subsystems
  - Windows Server 2019

6.3.2.3 *Substation Controller Computers*

The Substation Controller Computers will typical be rack mounted types of industrial grade to manage the environment in the substations. The computers will be selected to provide room for the extra serial interface cards or network interface cards needed to interface the equipment under control.

The computers share a KVM tray monitor for local management.

Each ESU will be equipped with a redundant set of Substation Controllers with the following characteristics:

- Two Industrial 19" Computer Siemens IPC547 family
    - Intel i7 processor
    - 16Gb RAM
    - 500Gb HDD
    - 2 Network interfaces
    - Windows 11

6.3.2.4 *ALCMS Application Software*

All computers will run the ALCMS software provided by ADB SAFEGATE. The software is copyright protected. The software is licensed to the airport, for the workstations included in our offer.

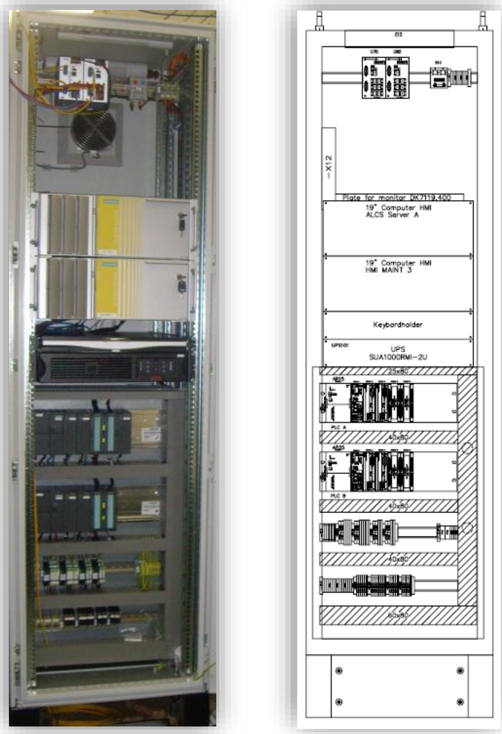
6.3.2.5 *Programmable Logical Controllers (PLCs)*

The Programmable Logical Controllers can be part of the execution level of the ALCMS system. Their roles are to work as gateways by translating the software commands sent by the substation controller workstation into commands for the different AGL equipment connected to the PLCs. Similarly, they collect equipment status to the ALCMS.

6.3.2.6 *Cabinets*

In each location, a cabinet housing the ALCMS components will be provided (unless space or other constraints require other solutions). The cabinet will typically contain:

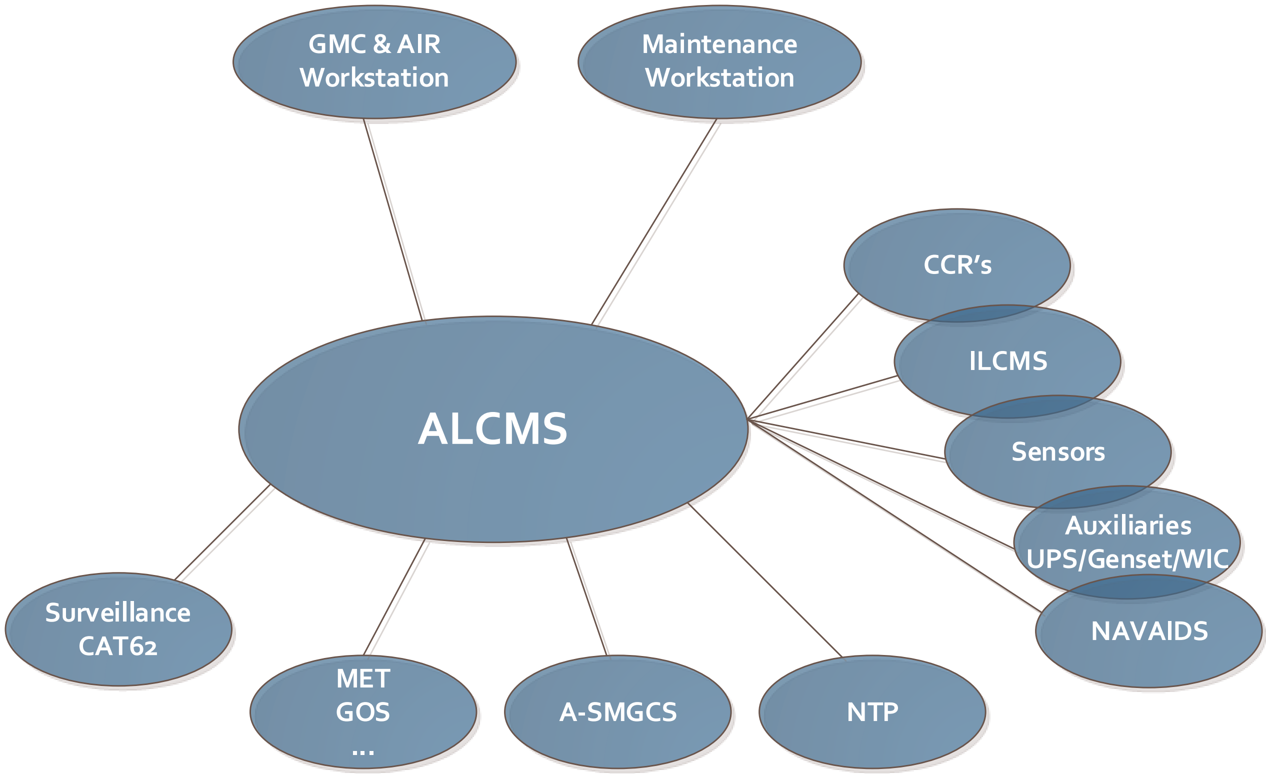
- Room for the computers.
- PLC Siemens S7 controllers, where needed to Interface equipment under digital I/O control.
- Network switches for the Inter location F.O. network.
- Network switches for any Local Area Network used to interface equipment.
- Network switches, Routers and Firewall equipment to interconnected external networks.
- UPS
- Required interface relays and terminal blocks for multi-wired equipment.
- Required 24/48 V DC power supplies.



Example of cabinet layout, final layout will be designed during the realization of the project.

6.4 Interfaces of the ALCMS with airport systems

The following diagram depicts the context of the Airfield Lighting Control and Monitoring system (ALCMS). It is assumed that the external systems and their interfaces mentioned in the diagram, provide sufficient information for the realization of the functional requirements and performance of the system.



As shown in the above diagram the Airfield Lighting Control and Monitoring System (ALCMS) is interconnected with several external systems and as such a major component in the realization of the safe operation of the Runways and related taxiway infrastructure.

Therefore following interfaces would be realized:

- Network Time Server Interface

An interface to a central Time server will be foreseen using the standard NTP interface. The NTP time will be used to synchronize all equipment making part of the ALCMS.

- Advanced Weather Operating System (AWOS)

An interface to the RVR system is foreseen, this interface allows for providing actual status of the runway lighting as well as receiving the actual visibility conditions that can be used by the ALCMS to propose the right operational category to the ATC operator..

- Interface to A-SMGCS

The interface to A-SMGCS provides control and status of Runway, taxiways, stop bars, protections of the Runways entrance, etc.... depending the needs of the A-SMGCS the ALCMS can provide different level of controls from long segments to individual lights ensuring the best Follow The Greens experience.

- Integration of Gate Operating System

The integration with the GOS will allow the automatic switching of the leadin lights based on GATE status, the interface will provide the possibility to control the segments related to the gates but also allows for the monitoring of the GATE status on the ALCMS HMI if the GOS system can provide this information.

- Integration of Surveillance CAT62

Integrating the CAT62 feed provided by the surveillance system will provide the ALCMS and the users with a situational awareness of the traffic as well as enabling the R1G features of the ALCMS solution.

- Other system

The above list does not itemize the interface limitation; ADB SAFEGATE's ALCMS support other interfaces depending on Airport needs.

For each of the ALCMS interfaces an Interface Control Document will be realized describing interface type and exchanged data. This document shall be agreed by all parties prior to the realization of the interface. It also will serve as basic for the interface test procedure of each individual system.

6.5 LINC360 - Individual Light Control and Monitoring System

The stopbars, taxiway center lines and Runway lighting will be equipped with the ADB SAFEGATE Individual Lamp Control and Monitoring solutions (ILCMS), these systems allow the ALCMS system to control and monitor individually each lamp fixture.

The ILCMS System allows the user to switch On or Off blocks of lamps without the need of using circuit selectors.

The control and monitoring messages are sent to the ILCMS Controllers via the ALCMS Network. The communication is Ethernet TCP/IP based.

The ILCMS Controllers are relaying the commands to the ILCMS remotes or intelligent lights via the series circuit.

6.5.1 Compliancy monitoring

ICAO regulations set maintenance objectives for serviceability of the Airfield Lighting. To comply with these the ALCMS maintenance teams will need to fix any lamp failures before the amount of lamps become critical for obtaining the maintenance objective limits. For the different light system both a percentage/amount limit exists, as well as the number of adjacent lamps failures not to exceed.

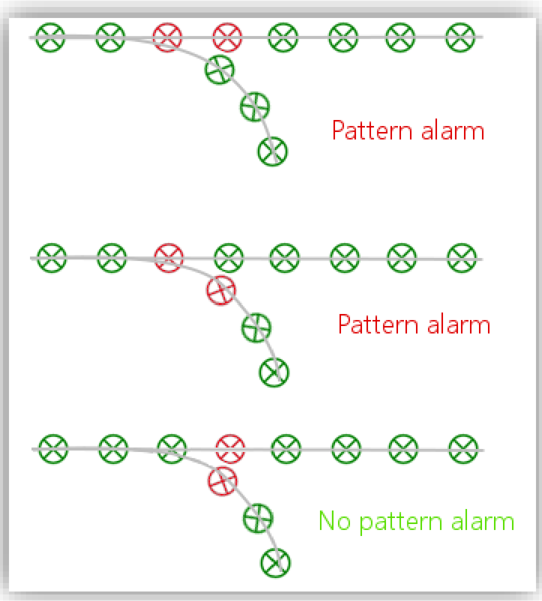
When using a LINC360 ILCMS not only will the maintenance team receive alarms for each failing lamps, but they will also be able to see the exact location on the overview map. This will allow the maintenance team to plan their effort and thus heavily reduce the operational impact.

The number of failing fixtures for the maintenance objectives are carefully set by ICAO to avoid any operational impact for aircrafts landing, taking off or taxiing. Naturally, the operational limits will allow a much higher number of failing fixtures than the limits set by the maintenance objectives. However, ICAO does not define any operational limits, as these will depend upon prevailing conditions and physical layout and configuration of the Airfield Lighting in general. The Cortex Advanced software allow to further configure Operational limits for both percentages and adjacent lamp failures, which will trigger Operational Alarms for ATC to react upon. The operational limits will be suggested as part of the design phase.

6.5.2 Adjacent lamp fault monitoring

One of the key advantages of the individual light monitoring, is that this allows the ALCMS to give alarms when lamp faults are occurring in an adjacent pattern.

Thus, when the ALCMS knows about adjacent lights in fault, no matter if the adjacent lamps are in different segments or on different circuits, a pattern alarm will be generated. Such an alarm should be treated with higher priority than a single lamp in error, since this might affect the pilots maneuvering of the aircraft in an unintended manner.



The number adjacent lamp limits will differ for maintenance alarms or for operational alarms and will further depend upon the visibility conditions.

The adjacent calculation will be configured to support multiple patterns, e.g. for the Approach Lighting System where both longitudinal and lateral patterns exists.

6.6 Stopbar Overrun Detection System

The stopbars protecting the Runways will be equipped with a Sensor sub-system which role will be to enhance the Stopbar mechanism by providing a fast re-arming of the Stopbar after the aircraft crossed the red lights and also to provide the ATC personal with an alert in case an aircraft or vehicle would cross the stopbar while not authorized (Stopbar ON).

The architecture of the Sensor System is based on inductive loop sensors.

Those sensors are installed across the taxiway that needs to be monitored and connected to a Central Communication Box (CCB) containing the necessary equipment to monitor the status of each sensor and provide reliable information to the higher ALCMS system.

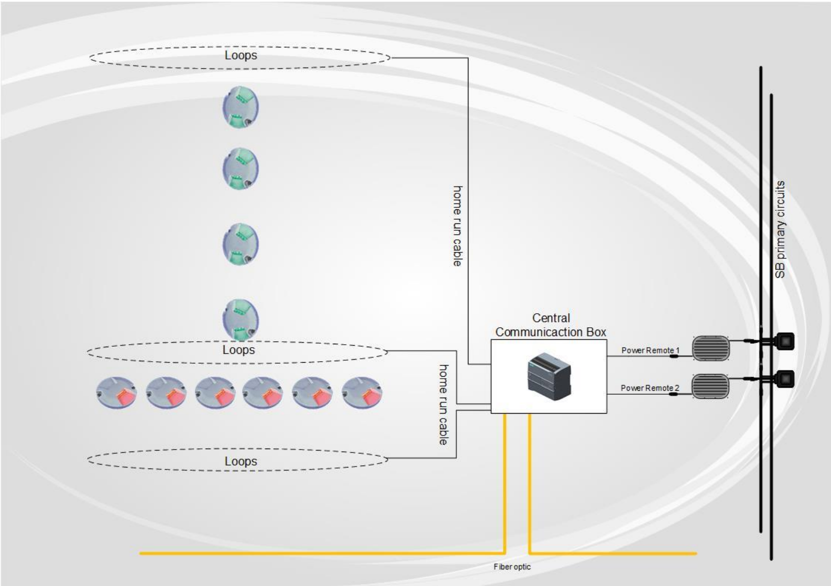
The communication between the CCB and the ALCMS will be granted by the usage of a fiber optic ring running along the runway and ending at the substation, providing fast and reliable data transmission.

The following schematic show how the overall System will look like, <u>the quantity of Sensors and the position of the Sensors can vary from stopbar to stopbar and depending on the expected functionality</u>.

There are 3 main zones equipped with sensors:

1. The Presence area, allowing to detect a vehicle standing in front of a particular stopbar.

2. The Stopbar sensor, allowing fro the fast re-arming and unauthorized crossing detection when a vehicle enters the stop bar line.
3. The Lead-on Sensor, allowing the switching off of the lead-on lights when the vehicle has left the Lead On lighting area.



Several different configurations/layout exists as the location of the sensors are not always possible due to field limitations. The Cortex Advanced ALCMS also allow flexible configuration of these alternative setups.

7 Functional description of the ALCMS HMI

7.1 Introduction

The objective of the HMI's are to provide the different users with the correct information shown clear and concise, and provide easy access to operational functions which match their current role.

This HMI is designed with intuitive look-and-feel and use of familiar icons to facilitate easy operation. Care was taken during the design to provide clear and unambiguous information to the operator at all time. Further, to ease operation at the tower environment, all the screens relevant to the ATC are designed to be easy to operate with a touch screen.

The system has HMI's designed for 4 main user group role

ATC controller:

The user operates one or more "areas of responsibility", for which the user needs quick access to operational status and control functions.
The lighting control functions is mainly dedicated to the ATC users, containing all means related to the sending of command to the various airfield ground lighting. The views and functions will depend upon the role, e.g. Runway Controller will control Runway, Approach, Papi lights and stop bars at runway entrances, while Ground Controllers will control Taxiway, Stop bars and Lead-on on the taxiway areas.

Maintenance:

The AGL monitoring and troubleshooting part is dedicated to the maintenance service team. The HMI will both provide understanding of technical aspects of of airfield lighting errors, as well as the operational aspects caused. The functions for fault findings, fixing and testing are in focus.

Supervisor Controller:

This user are to get a complete operational Overview to make operational decisions about usage of the airport facilities. The Supervisor will also be able to modify "ATC" system settings and preferences.

Supervisor MAINT:

Besides acting as a maintenance user, the Supervisor Maintenance are also able to modify system settings and behaviours.

The functionality provided depends on the logged in user and which user group the user belongs to; this will grant access to certain function while other functions will be blocked.

ALCMS Functionality				
HMI Basics	Operational functions	Maintenance functions	Alarms handling	Safety
User interface	Control areas	Equipment status and fault evaluation	Alarms visualisation	Failsafe mode
Users	Runway control	Maintenance control	Alarms filtering	Software redundancy
Symbols	Taxiway control	System variables	Alarms management	Failure recovery
Display options	Stop bar control	User management	Alarm types	
	LVP	Data logging		
	Dynamic routing			

7.2 User management

The system offers an Active Directory solution, that targets airports that want the system to be integrated with the airports own user management database (now or in the future). Here the management typical are done by the Airports IT department, who needs to join each individual users to the ALCMS_GROUP that give them one or more of the user role rights within the system. For the user's perspective, then one password will be used whether the user logs in on the office computer or on the ALCMS computer. At the same time it allows the airports IT department to manage the password policy and add more secure access methods like two-factor authentication. In this solution the authentication of the user happens via the Windows login.

7.3 Control of operations

As indicated in the previous chapters, the overall ALCMS may comprise multiple computers, which results in the necessity to control the access to the airfield lighting equipment. Indeed, controlling the equipment from two locations simultaneously could result in unexpected behaviour for the operators if no clear control mechanisms are set in place.

The ALCMS system can be configured in a way that only one of the system computers is allowed to enter commands into the system at a specific point in time. Mostly, the control will be granted to the ATC-computer, used by the ATC operators. Maintenance HMIs located in a substation building or any other location must request and acquire the control before they can operate the system.

Now, as the role of the Maintenance team is to maintain the airport operational they need a mean to control equipment individually without disturbing the ATC operation.
To permit this, the ALCMS foresees a mechanism which allows the maintenance user to disconnect equipment for maintenance purpose which allows him to control and monitor that particular equipment.

The ALCMS has been designed to make the function of ATC controller easier by grouping the commands in compliance with the recommendations of ICAO and on the other hand to allow maintenance staff to isolate a group of fixtures for maintenance, whether belonging to a segment or circuit.
Three levels of control are provided for sending commands to AGL equipment, these are further depicted in the document:

- The Automatic Selection of Visual Aids controls globally all circuits related to the runway in use by setting the visibility conditions to match the outdoor weather conditions.

- The AGL Function Individual Brightness Selection controls one particular AGL function. This control level allows switching ON/OFF one AGL function or increase or decrease the default step by 1 (or more) for fine tuning, under request of pilots or local variation of weather.
- The Maintenance Mode (Individual Level) controls individually every regulator independently of the other settings. This is a function available only for the maintenance users and before this is allowed they need to request permission and get permission granted by ATC user. The regulator is then set in Maintenance mode, where commands from ATC are ignored and the serial loop can be controlled by maintenance e.g., for fault-finding test and for inspection.

Besides the different level of controls, the CORTEX Advanced ALCMS also provides Area of Responsibilities, allowing the ATC to separate the controls of the different areas of the Airport and ensuring multiple operators can operate their own areas without interfering with the others.
The System provides the possibility to select one or multiple areas depending on the operational process of the airport which can differ during peaks hours and calmer periods.

7.4 ATC HMI screens

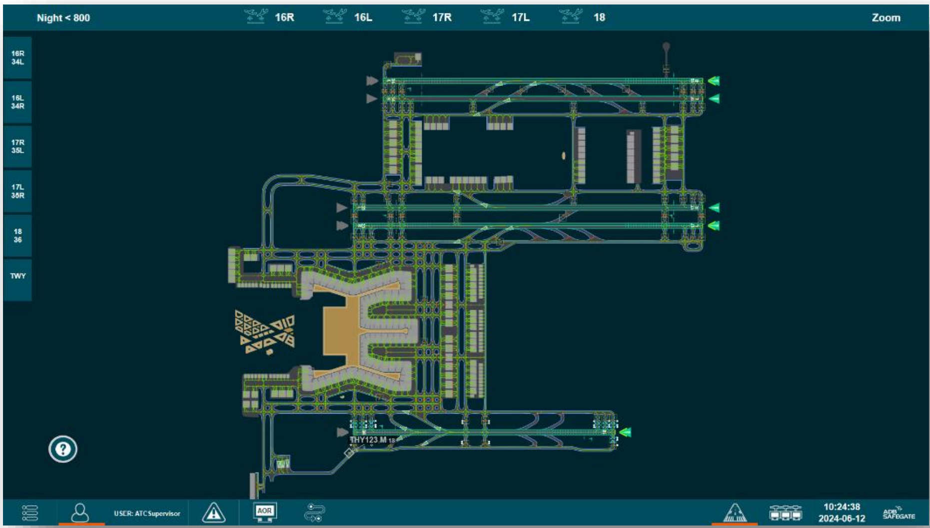
Following chapters provide a high level description of the different screens the HMI will provide for ATC purpose, these screens will be clearly defined during the Design phase of the project ensuing all graphical requirements of the airport are considered within the capabilities of the product.

NOTE:
The different screenshots presented in this document give an example of typical system implementations. Project-specific implementations (like screen layouts and control possibilities) might differ as the number and configuration of airfield lighting elements, runways and taxiways might change from the examples presented in this document.

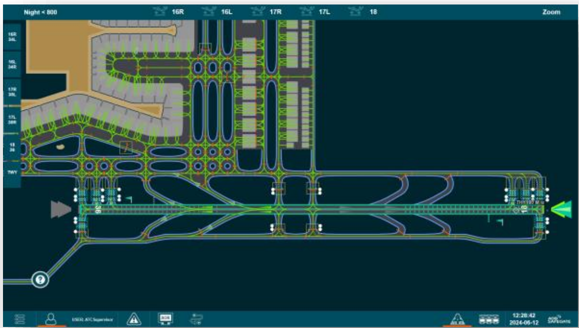
From a functional point of view, however, the control and monitoring possibilities offered by the software will be quite similar to the ones described in this chapter.

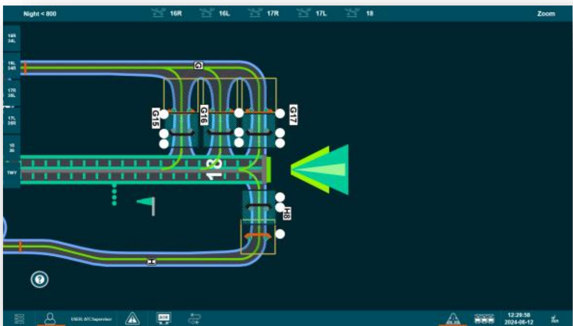
7.4.1 Airport Overview Window

This view is mainly for the operational users, Air Traffic Controllers and Ground Controllers. Using this view, the control of runway and taxiway lights can be made.



The Airport Overview will at a glance give the user the status of every monitored light in the airport. To enable detailed view of complex areas, the Airport Overview is Pinch-Zoomable ensuring each user can zoom to the level of details he’s needing to perform his activities.

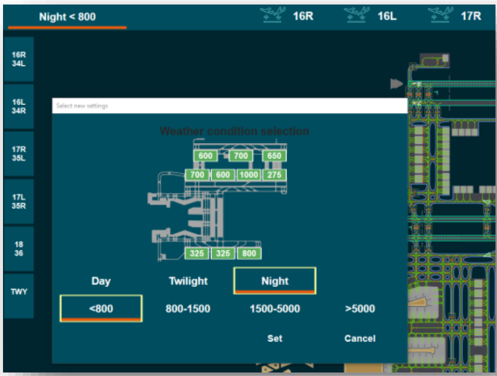




The Airport Overview Window contains multiple areas, further described in the following subsections:

7.4.1.1 *General Condition Selection*

The upper left part of the screen will be used for automatic control, based on the general light conditions in the airport. The general condition settings selected, will automatically change the brightness settings on the runways in use.



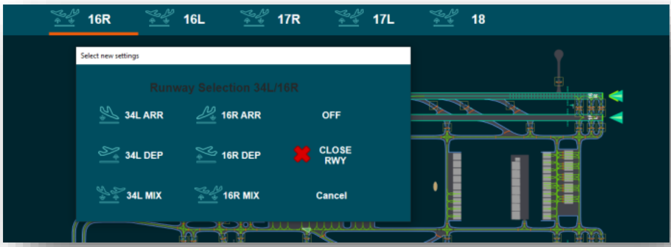
Clicking the General Condition button will open a menu, where selections must be made for the following settings:

- Day, Twilight or Night
- Visibility (RVR)
- Operational category

This will enable swift change of light settings on all runways simultaneously, based on the current weather conditions, and the current runway utilization.

7.4.1.2 *Runway Utilization Selection*

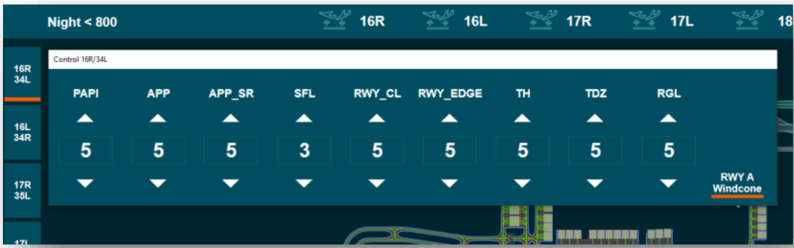
In the top right-hand corner of the screen, the user will find oblong buttons showing the current utilization of the runways.



7.4.1.3 *Individual Function Control*

By opening the Individual Function Control menu, it will be possible to make individual brightness selections for each light function in the area under control. This will override the automatic brightness selection, as described in earlier chapters.

In case one-or-more of the individual function brightness selections are deviating from the recommended settings, as dictated by the Automatic Brightness Table, the Individual Function Control menu button will glow in yellow color.



By further opening the Individual Function Control menu, the function(s) deviating from the recommended, will also glow with a yellow background.

7.4.1.4 *Overview Map*

The Overview Map presents a “live” representation of the individual Airfield Lighting Status for Runway and Taxiways.

Visualization of the AGL feedback’s:

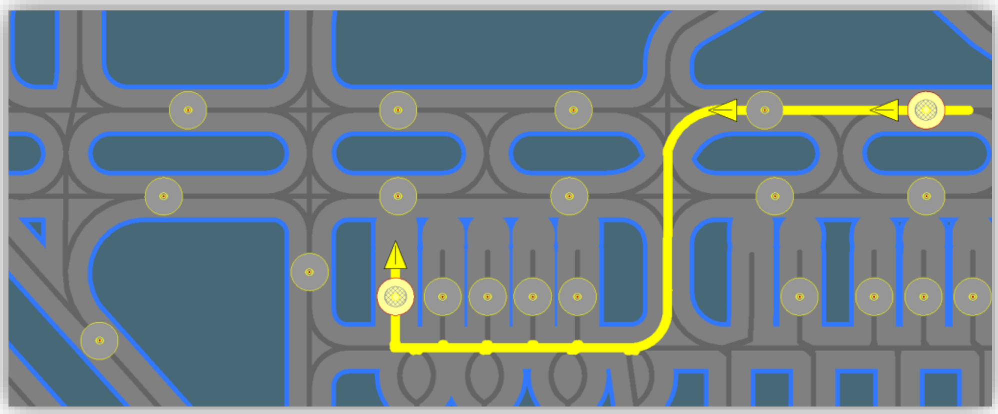
1. Off – typical Grey
2. On – typical green or colour indicating the actual colour of the equipment.
3. Warning (Maintenance users only) – maintenance limits exceeded.
4. Partly On – typical lime. On and still no alarm, but maintenance limits exceeded.
5. Alarm – typical red (flashing until acknowledged). Exceeded operational limits.
6. Maintenance – typical pink. Under control of maintenance. Two shades indicate on/off.
7. Out of Service – typical purple. Lights are non operational and off.

All colours can be configured as requested.

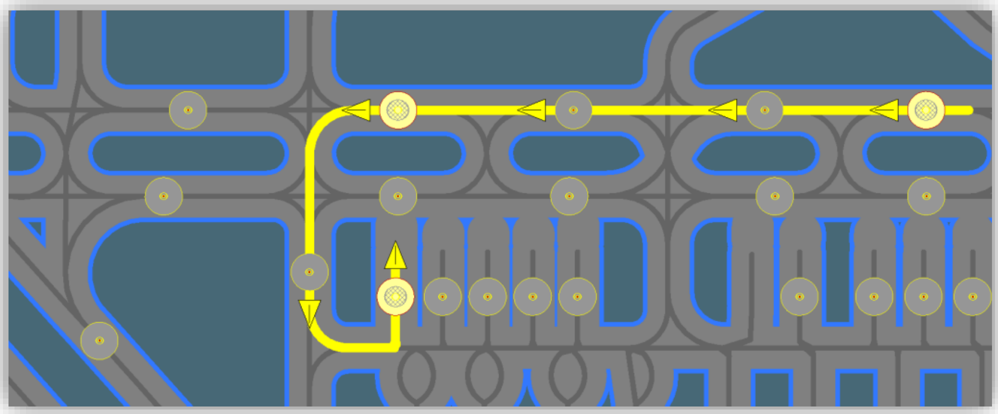
7.4.1.5 *Taxiway – Dynamic Routing*

Due to the vast amount of ILCMS-enabled TCL in the airport, it is an obvious choice to enable Dynamic Routing for the taxiways.

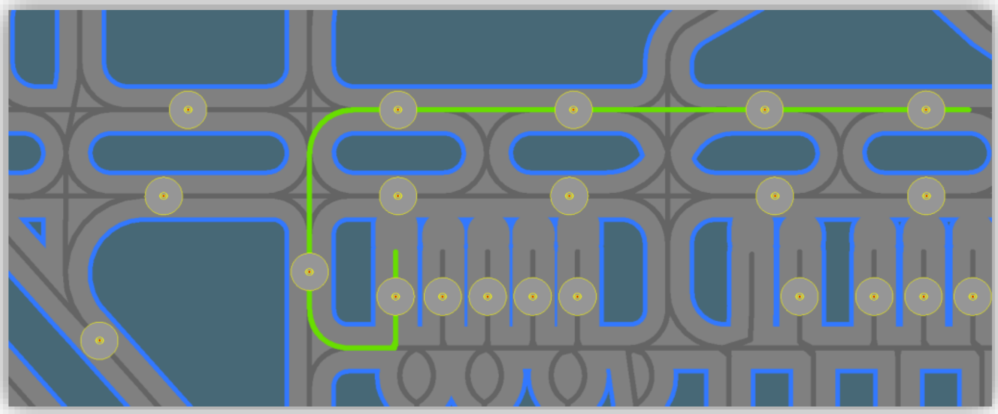
This will enable the operational users to create routes, by the use of route selection points. This is easily done through touch-enabled monitors. Using a start- and end selection point, the system will suggest an optimal route between these two points, and display this suggestion in yellow.



If the user for some reason needs to be directed via a specific path from start- to end, VIA route points can be added.



If the route is accepted by the user, the Execute button should be pressed in a route window, visible while modifying routes. This will make the ALCMS turn on the appropriate TCL lights to form the requested route. When bi-directional ILCMS taxiway lights are available, the route will be only in the direction chosen for the aircraft.



The standard Dynamic Route package allows for a bundle of other features, including:

- Multiple start points
- Multiple end points
- Saving / loading / renaming of routes
- Closure restrictions (Temporarely close an area for all routing)

These functionalities will however not be further described here, but are included.

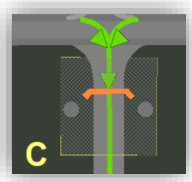
7.4.1.6 *Stop bar Control*

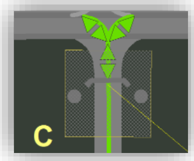
The Airport is equipped with Stop bars and lead on sections.

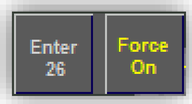
A stop bar is composed of the stop bar itself (red lights) but also the following lead-on (green taxiway centreline lights) segment which is at least of 90 m long, they must be interlocked, this means that when the stop bar (red) lights are On, the lead-on (green) lights must be Off. This functionality is achieved automatically by the ALCMS system ensuring respect of the ICAO standards.

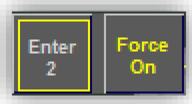
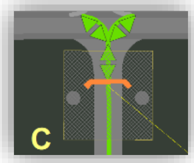
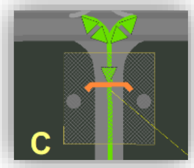
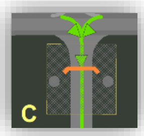
When the stop bars are on, it is possible to control these individually. To avoid accidents, only One stop bar protecting a particular runway can be cycled at once; they are interlocked to only allow one vehicle entering the runway at a time.

The primary method of stop bar control is by doing sequence control. This allows to cycle through a complete set of four different states, ENTER, LEAVE 1, LEAVE 2 and back to IDLE. This will be done by touch-sensitive areas, directly on the location of the stop bars in the Airport Overview.

Stop Bar Sequence Control	
IDLE state: • The stop bar sequence is triggered by pressing on the touch sensitive areas around a stop bar. This makes the stop bar go to the ENTER state	

<table>
<tr><th colspan="2">Stop Bar Sequence Control</th></tr>
<tr><td>ENTER state:
The stop bar turns off.
Both lead on segments will activate.
A timer reset button will be displayed in proximity to the stop bar.
The timer reset button will reset the time allowed for entering the runway. The button will give a warning five seconds before the stop bar turns back on.
A Force On button will be displayed in proximity to the stop bar.
The Force On button will allow the user to terminate the sequence and force the stop bar on and the lead on off</td><td>



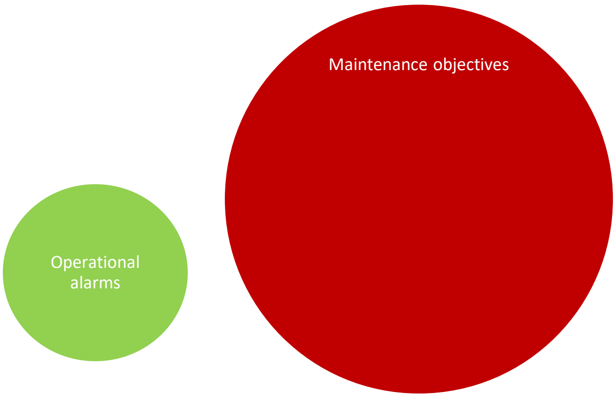

</td></tr>
<tr><td>LEAVE 1 state:
After a predefined time, or the stop bar sensor detection, the stop bar will turn on to prevent other aircrafts from crossing.
All lead on's stay active to facilitate the currently passing aircraft.</td><td>
</td></tr>
<tr><td>LEAVE 2 state:
After a predefined time, or the leadon sensor detection, the lead on immediately following the stop bar will turn off to further eliminate a potential confusion by the lined up aircraft.
The remaining lead on's stay on to facilitate the currently passing aircraft.</td><td>
</td></tr>
<tr><td>IDLE state:
When the sequence is finished, all lead on's turn off and the stop bar remains on.
This is the state the stop bar was in before the sequence has been triggered.</td><td>
</td></tr>
<tr><td colspan="2">Note: Default time for ENTER, LEAVE 1 and LEAVE 2 states is 30 seconds. This time can be changed individually for each stop bar by a Supervisor user.</td></tr>
</table>

If the airport is equipped with inductive sensor loops. This allows to interconnect with the stop bar sequence control, automatically advancing from ENTER to LEAVE 1 state, when stop bar is crossed, furthermore advancing from LEAVE 1 to LEAVE 2, when the last sensor is crossed.

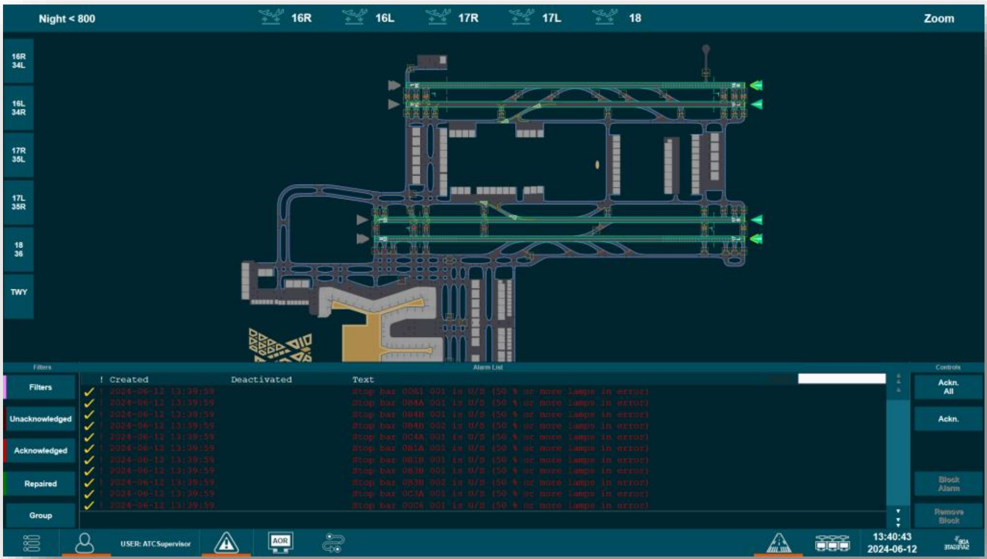
This will also allow the surveillance of unauthorized stop bar crossings. In case an unauthorized crossing of the stop bar is detected, the ALCMS will alert the ATC user by a red/yellow blinking circle around the incursion location, plus a sound will alert about the incursion on the controller workstations.

7.4.1.7 *Alarm list view*

The ATC Alarm list is meant to provide the ATC personal with the information they need to verify the operational conditions of the airport therefore the provided alarm list for ATC will purely provide alarms that have a direct operation impact ensuring the ATC operators are not disturbed with pure maintenance objective alarms.



For this purpose, the Airport overview displays an operational alarm list that will be used by the ATC operators to get a direct understanding of the actual operational situation of the airport.

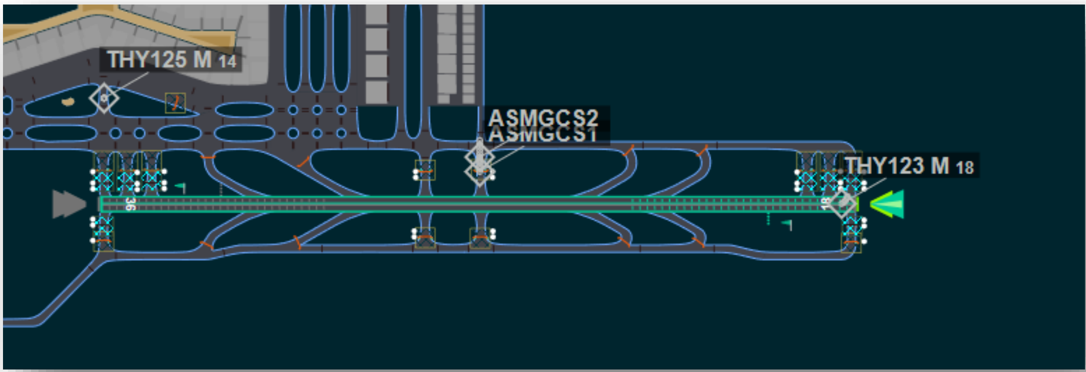


7.4.2 Surveillance data integration

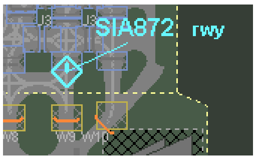
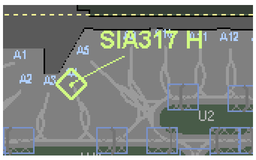
The proposed ALCMS is ready to integrate the surveillance data provided by the Multi Sensor Data Fusion system in a CAT62 or CAT11 format.

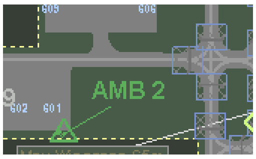
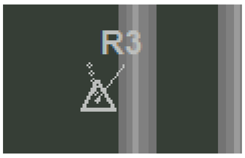
The integration of the surveillance data enables the possibility to track traffic on the ALCMS airport overview, providing situational awareness to the different users.

This feature is mainly used by the ATC operator to visualize the tracks of every moving object on the Airside area but can also be used by the Maintenance team to understand the actual traffic of the airport and allowing to better plan their own activities.



The different tracks are represented using symbols and colours to ensure a clear understanding of the information that is displayed, these colours and symbols can be adapted based on the local preferences.

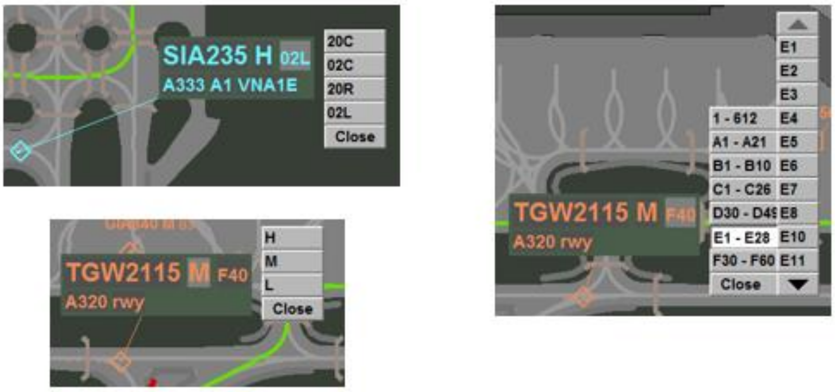
Graphics and Colours	Description
	Inbound and Concerned
	Outbound and Concerned
	Unknown (ADEP/ADES Missing) and Concerned

	Vehicle
	Unconcerned (not in AOR)
	Multi-Sensor Aircraft Track
	Multi-lateration only track
	SMR only track
	Vehicle track

Labels are configurable allowing different information to be displayed:

Possibility to overwrite missing or faulty data using drop downs, providing the possibility to adapt:

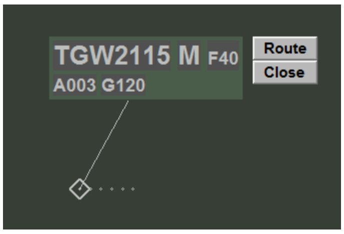
- Destination, Runway holding point or Gate
- Aircraft type for wingspan restrictions
- Wake
- Callsign



The integration of the Surveillance data also enable additional features related to the routing and guidance of aircrafts, these functionalities will be mainly used as disaster recovery plan in case of failure of the main A-SMGCS solution to ensure the continuity of the operations in a safe and efficient manner.

7.4.2.1 *Assignment of Aircraft to routes*

It shall be possible to assign a particular aircraft to an individual route by selecting the track label and choosing a route in the dropdown list.



Another possibility is the automatic assignment of all aircrafts to the defined collective route. This assignment happens automatically when the aircraft enters the predefined collective route.

If an aircraft deviated from its assigned route, the ALCMS will alert the ATC operator responsible for this area.

7.4.2.2 *Infringement Alerts*

In case a closed area has been defined and if an aircraft would enter this zone, the ATC operator will receive an immediate alert.

7.5 Maintenance HMI

Following chapters provide a high-level description of the different screens the HMI will provide for the maintenance team, these screens will be clearly defined during the Design phase of the project ensuing all graphical requirements of the airport are considered within the capabilities of the product.

NOTE:
The different screenshots presented in this document give an example of typical system implementations. Project-specific implementations (like screen layouts and control possibilities) might differ as the number and configuration of airfield lighting elements, runways and taxiways might change from the examples presented in this document.

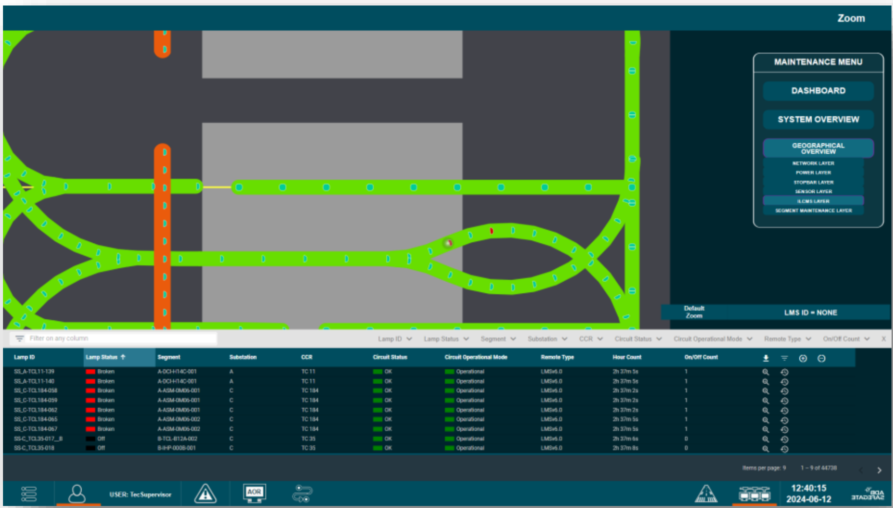
From a functional point of view, however, the control and monitoring possibilities offered by the software will be quite similar to the ones described in this chapter.

7.5.1 Maintenance map overview

When a maintenance user is logged in to the system several additional functionalities are enabled, these will provide the maintenance team with a set of tools that facilitate the troubleshooting of the AGL infrastructure.

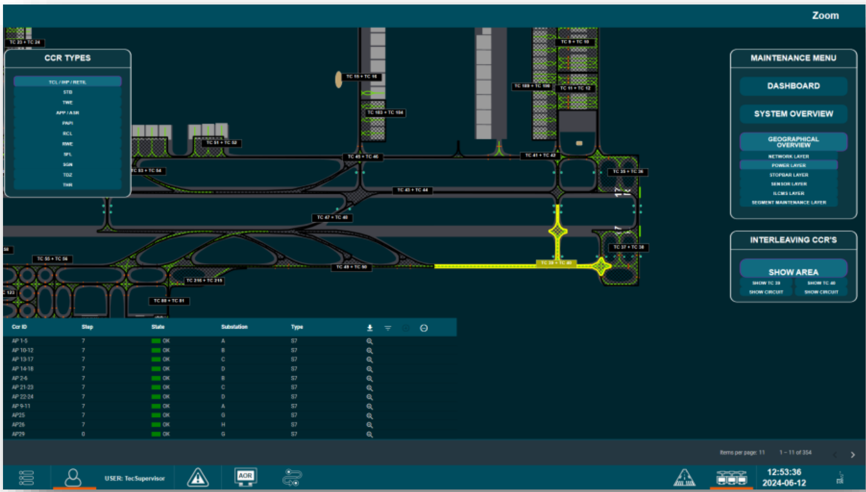
7.5.1.1 *Individual Light view*

The individual light view add an extra layer showing each light in their true color, each of these lights is clickable and will provide additional information such as the ID, the colour, the segment it belongs to, the CCR it belongs to as well as substation information.
The view also come with a list of lights, providing details on every light individually monitored by the ALCMS, this view provides deails about the light, such as its ID, state, location, segment, type, hour counters and can filtered based on any of its column easing the research part of the maintenance team. Each entry of this list provides a locator function that allows to zoom directly to the light the user is looking at, removing the need of opening any drawing to locate this particular light.

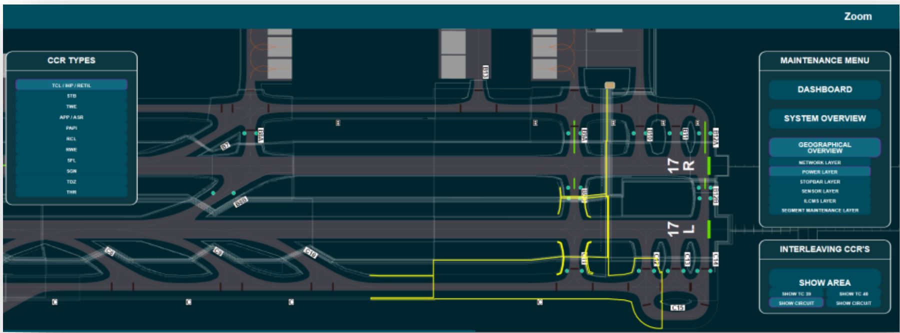


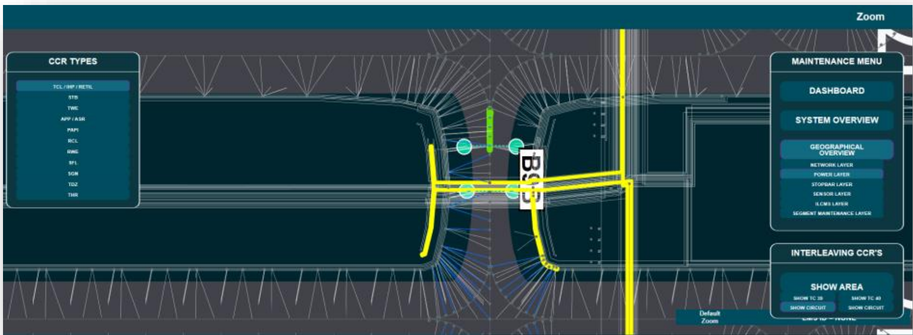
7.5.1.2 *Primary and secondary circuits view*

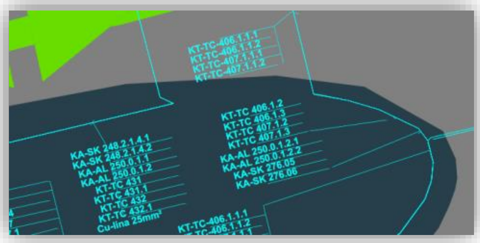
To further facilitate the activities of the maintenance team, the system also provide the capability to import any details available in the autocad drawings, such as the primary and secondary cabling. This view will allow the user to display the area powered by a particular CCR:

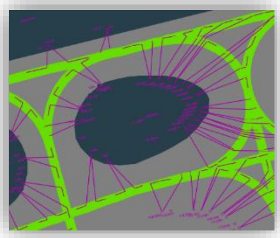


Or the circuit layout of a particular CCR, including all primary and secondary cabling layout:



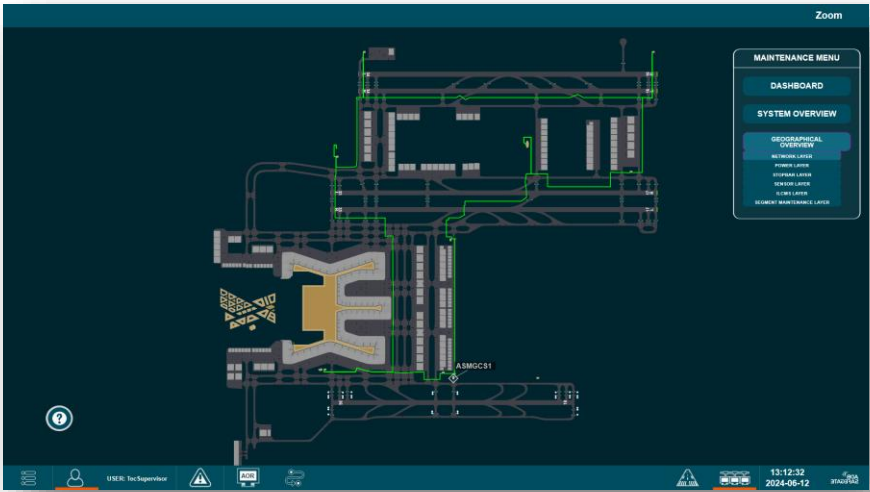






7.5.1.3 *Fiber optic network view*

Similar to the circuit view, the ALCMS can display the different fiber optics used to network the ALCMS and its equipment giving the status of the fiber as well as their routing, easing the fault finding.



7.5.1.4 *Sensors Overview*

When the airport is equipped with sensors to enhance the stopbar operations, the system can display each of these sensors providing a direct view of their operational state, as well as their detection signals allowing the maintenance users to easily verify the good state of the sensors.

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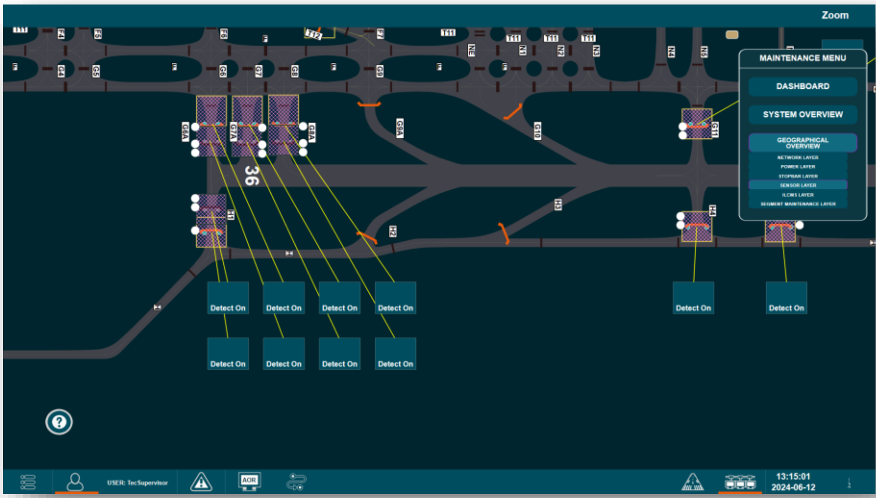

7.5.1.5 *Maintenance areas*

The maintenance users can request to set into maintenance mode each individual object, however this would be cumbersome if a larger area is to be worked on. Thus two other possibilities exist form the overview map.

The possibility to draw a "polygon" representing a "Closed Area", with a Label that indicate to ATC the area where no traffic should enter. Note. While the maintenance team might only work on a single circuit in e.g. an intersection, then operational wise ATC must understand and ensure that all taxiways that leads towards this intersection is closed.

Another tool called Maintenance Area Handler allowing to prepare a larger area for maintenance. When the area is "designed" it can later be activated and deactivated multiple times. This is e.g. for planned maintenance that e.g. takes place several nights in a row, but which are operational again during day-time. A nice feature in MAH, is that after a user has added just a single segment within an intersection to the Area, then the user can in auto-mode ask MAH to "expand" the area so all taxiways leading into the this segment is included.


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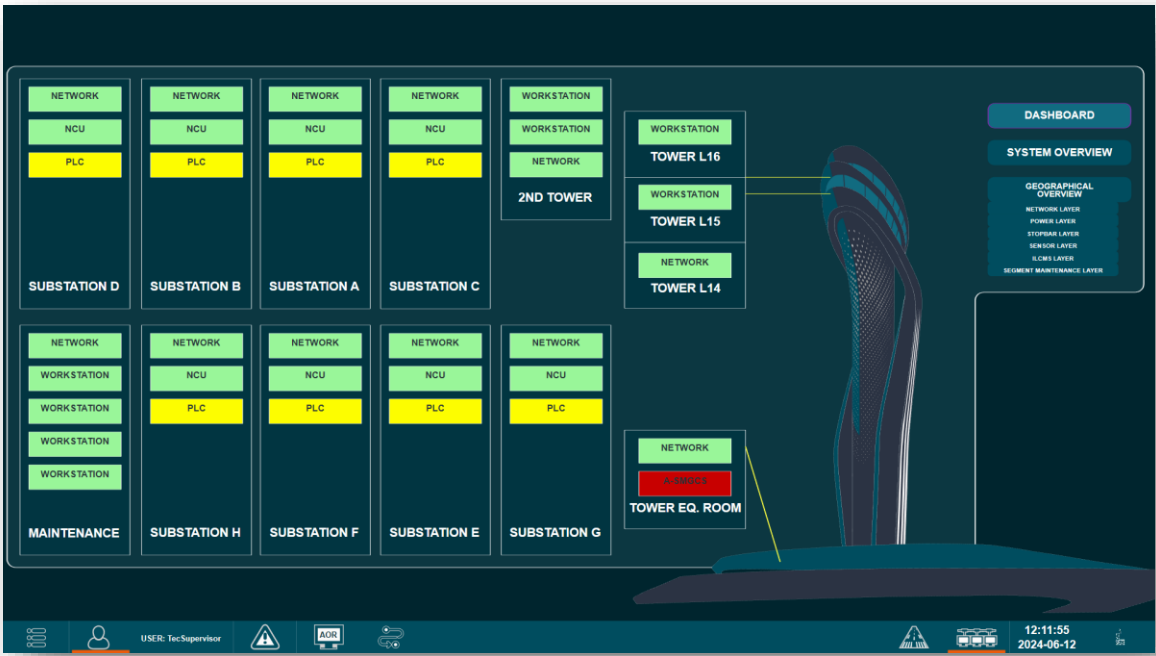
7.5.2 Maintenance System Overview Window

The Maintenance System Overview Window gives a graphical status representation of the backbone of the Cortex Advanced ALCMS system for general computer, software, network, and interfaces status. This window is the starting point of maintenance and troubleshooting activities.

It provides a direct view on the status of the main components per location, per equipment type, informing immediately the maintenance team of the healthiness of the overall system without the need of digging into any details ensuring an efficient high-level verification of the actual situation of the Airport infrastructure.

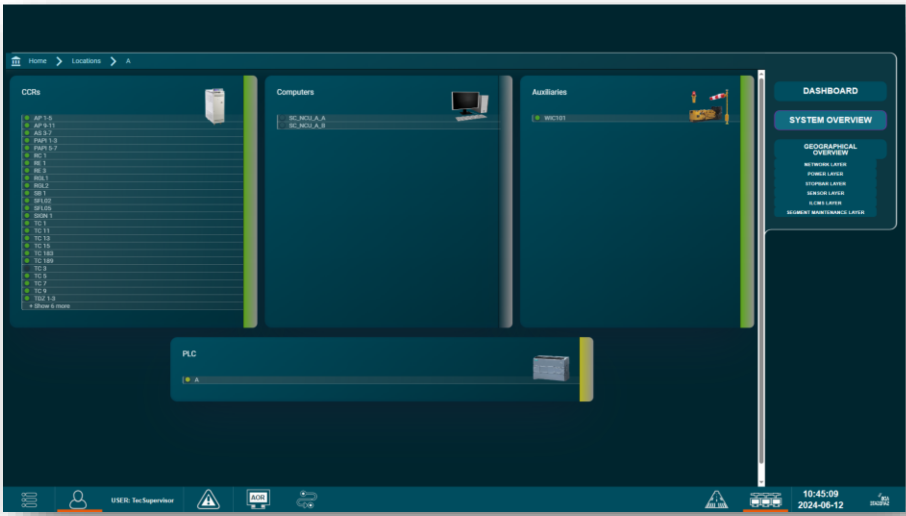


When clicking on any of the high-level representation, detailed information is displayed allowing the maintenance user to dig into the individual information of each component control and monitored by the ALCMS solution.

To ensure the best user experience for the maintenance users, it is possible to click on any location to get status of all the equipment of this particular location, or on an equipment type to receive details of all the equipment of this particular type.

7.5.3 Substation Window

The Substation Window is mainly used for maintenance purposes and gives a view of the different components located in the substation. Most of the time, these will be computers, CCRs and I/O auxiliaries. By clicking on any type or specific equipment, the ALCMS will display a different view providing further details.



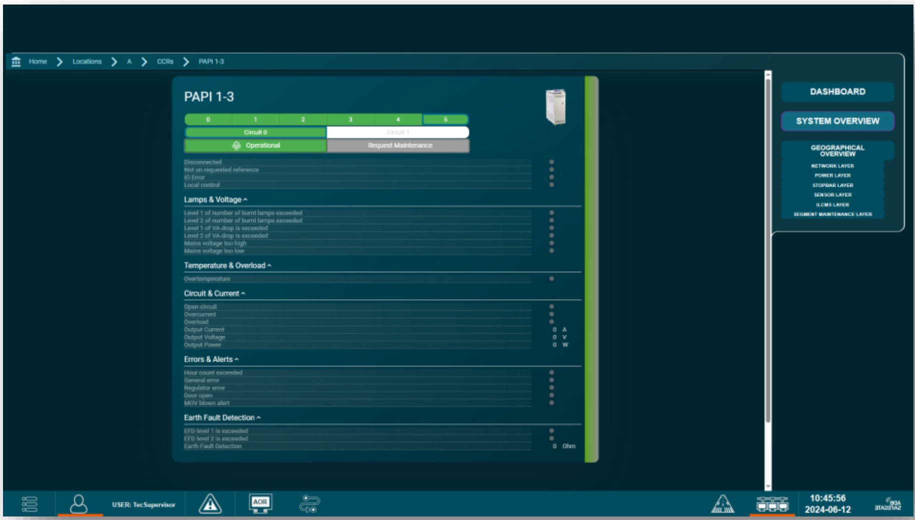
7.5.4 CCR equipment monitoring

When clicking on the CCR type, the System display a view detailing the status of each of the CCRs.

Clicking on any of these CCRs will open a detailed view of this particular CCR providing further details on the equipment.

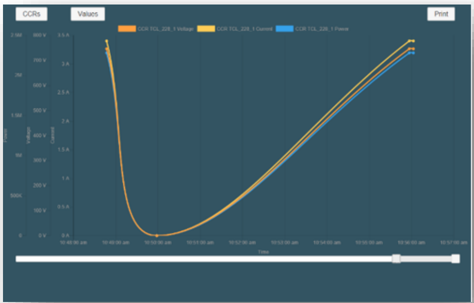
7.5.4.1 *CCR maintenance control and monitoring*

Each CCR is represented by an icon that reflects the status of the CCR (on, off, alarm, maintenance). By clicking on the icon, the CCR View for the selected node will show.



The view will display detailed information like output current, earth fault measurements, operational times, etc.
The maintenance operator can also put the CCR into maintenance mode and control it individually, when the CCR is set to maintenance mode it cannot be controlled by ATC, ensuring the maintenance team execute their activities in a safe environment, the ALCMS will memorize any ATC command send during this period and apply the last requested state to the CCR when back to operation.

For each CCR that provides analogue values, it is possible to show the CCR Graph. The possible animations can be selected between Current, Voltage, Power, and Earth Fault (Insulation) measurements.



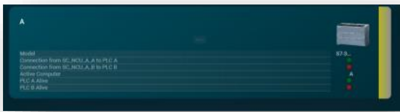
The CCR data can further be shown in tabular form and exported for external analysis.

7.5.5 ALCMS equipment monitoring

The Several equipment making part of the ALCMS are also monitored, each of those components can be further analyzed by opening its respective detailed view.

Computer's view:

PLC's view:



7.5.6 Alarms and events Window

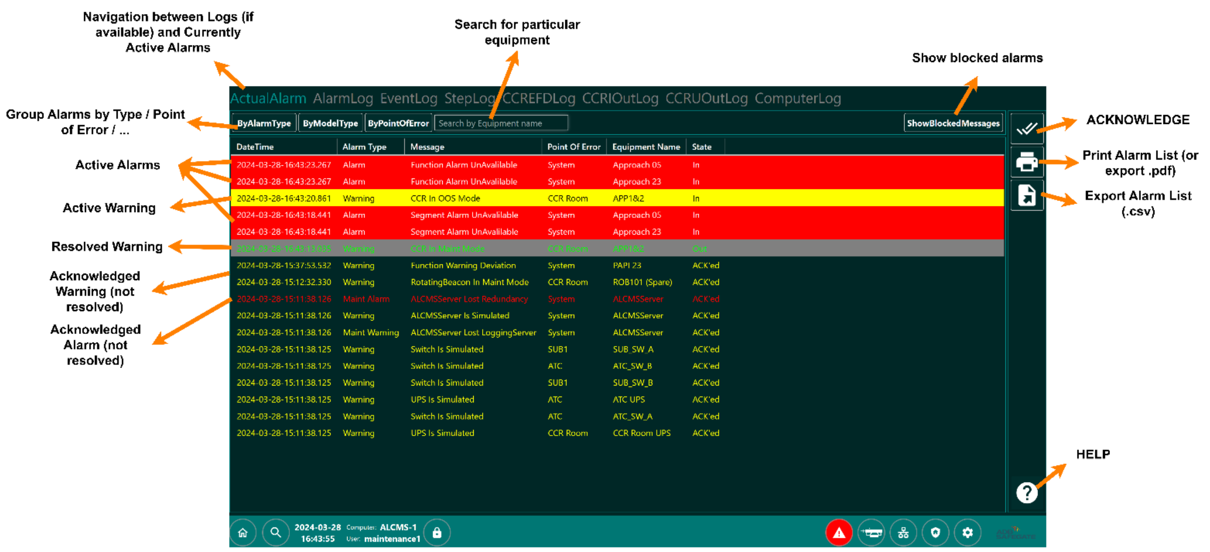
The system provides textual alarms to give the users clear and concise information about the causes and consequences of any failures. When alarms situations occur, both the related graphic on the overview map and/or E-Safe will show the failure, and at the same time the related alarm texts will appear in the Alarm Windows.

When the Alarm Window menu button is selected from the navigation section, the Alarm Window will be shown. This page displays information of all the alarms currently active in the system and is an important tool for troubleshooting the system.

The handling of alarms is based on a defined workflow that ensures that all the alarms must be acknowledged by the users before they are cleared from the alarm browser.

Also, as several levels of alarms (and warnings) are available, the contents of the alarm window will be adapted to the currently logged-in user. This ensures for example that ATC users only are presented with the information that is directly relevant to them.

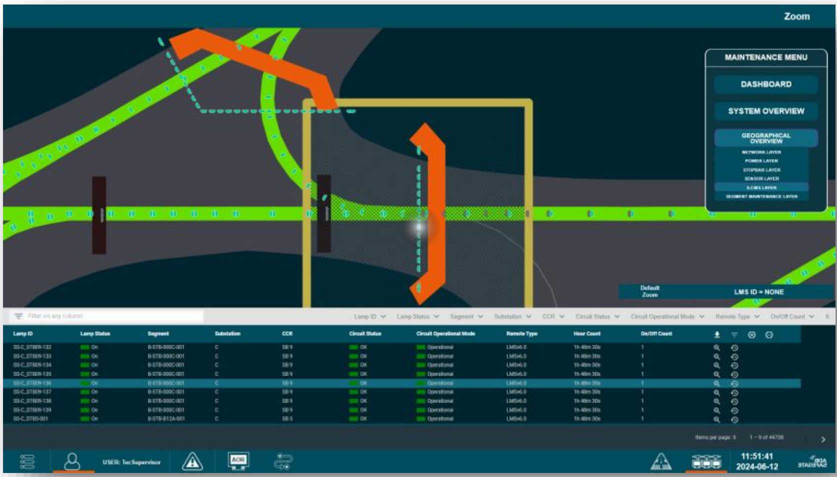
Note also that alarms are accompanied by an audible sound to attract the user's attention.



The Alarm windows has multiple possibilities to filter the list.

For the maintenance users the ability to filter on "related alarms" is very handy to find out what can be the route cause for an operational alarm, or what consequences does a CCR alarm have for operations.

If the user select an alarm in the list it is possible to "Locate" the object on the Overview map, as the object then will flash. This specific help to locate fixture alarms. When a fixture alarm is selected in the list the segment will start to flash on the overview map and the Fixture will be encircled by a ring. It shall be possible to zoom directly to the object in alarm, easing the search process for the maintenance user and removing the need of opening any drawing.


Zoom
MAINTENANCE MENU
DASHBOARD
SYSTEM OVERVIEW
GEOGRAPHICAL OVERVIEW
LMS ID = NONE
USER: TecSupervisor
11:51:41
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