ActiveAhead® Self-Learning Solution - System Description

Document revision 1.0

DISCLAIMER

The information presented in this guide is only instructional and is not to be considered definitive. No guarantee of absolute correctness of the information presented in this guide can be given. However, the information has been carefully reviewed and is considered accurate at the time of first publication date.

Helvar Oy Ab reserves the right to amend the contents without prior announcement.

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About this document

Purpose

This document describes the main features, behaviour, self-learning capabilities and system parameters of a Helvar ActiveAhead® solution. After reading this document the reader will understand how an ActiveAhead solution works in practice, which parameters the solution measures and adjusts, what are the default values and ranges of system parameters, how the system learns during the initial learning period, how it behaves when it detects changes in the environment, how it adjusts and controls both individual and grouped ActiveAhead luminaires and how the user can change or reset learned behaviour.

Intended audience

This document is written for resellers of ActiveAhead solutions, lighting specifiers, installers and luminaire designers as well as anyone interested in how the Helvar ActiveAhead® solution is designed to operate.

Prerequisites

There are no special prerequisites for reading or understanding this document. General understanding of public and office space lighting control systems and their use is useful but not mandatory.

Software version compatibility

This document version (1.0) of the ActiveAhead Self-Learning - System Description reflects the features of the ActiveAhead firmware version 1.5. Earlier firmware versions may not contain all the features described in this manual version, the described functions may differ and possible future versions of the software may contain features not listed in this document version.

Introduction to ActiveAhead features

This section describes ActiveAhead solution features and behaviour and which components the solution and its individual luminaires consist of. Furthermore, some basic information regarding concepts and terminology are also introduced.

Energy savings and user comfort

ActiveAhead is a movement enabled smart energy lighting saving solution which automatically controls the light output of wirelessly communicating luminaires by considering the detected movement of persons, the amount of available daylight and a set of user configurable parameters.

Once installed the luminaires will establish a mesh network based on wireless Bluetooth low energy technology. Luminaires then exchange information between themselves to help identify common movement paths persons use on the site. This makes it possible for the system to learn to predict where light is next needed so that luminaires can react literally one step ahead of a walking person.

In addition to the energy savings offered by the smart lighting, the ActiveAhead solution offers savings provided by simpler installation with no control wiring. Typically, ActiveAhead solution provides good lighting experience in a space with no need for on-site adjustments. However, customization such as adjustment to lower and higher light levels, timeout values, groupings and wall panel assignments are possible by using a mobile phone with the Helvar ActiveAhead® Mobile App installed on it.

The ActiveAhead solution is well suited for simple offices with open office spaces, corridors, social areas and small to medium sized meeting rooms with basic lighting control needs. In addition, ActiveAhead solution's ability to predict movement patterns offers many benefits in applications such as stairways, corridors and parking garages. Lighting refurbishment projects in which it is not possible to add control cabling are well suited to be implemented using ActiveAhead components.

Artificial intelligence

ActiveAhead solution is based on an artificial intelligence algorithm which collects and analyses movement and light detected by sensors in each ActiveAhead luminaire. After enough movement data has been collected for the algorithm to identify common movement paths, predictions can be made to dim the light according to movement detection notification messages received from neighbouring luminaires.

Mesh networking

ActiveAhead solution utilizes wireless communication based on Bluetooth LE (Low Energy) for exchanging data between neighbouring luminaires. In a pure mesh network there are no predefined routing tables to be followed when data is sent. Instead data is relayed forward by each node to other connected nodes. In case a link between two nodes is broken the data will still get through in case there is another way to get to the node behind the broken link. Data will not get looped in the network as the nodes ignore data they have already received. A simplified sketch of a wireless mesh network is shown in Figure 1.

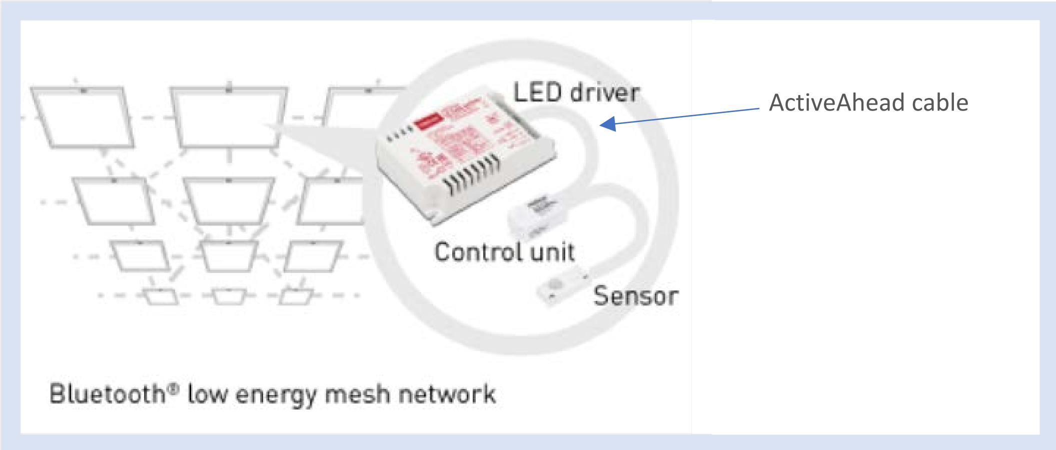


Figure 1: Simplified sketch of a wireless mesh network.

Luminaires

ActiveAhead compatible luminaires have pre-installed software and work autonomously from the moment they are powered on. ActiveAhead luminaires consist of the following ActiveAhead components:

- ActiveAhead compatible LED Driver
- ActiveAhead Control Unit
- ActiveAhead compatible sensor (in this document Active+ Sense)
- ActiveAhead Cable

Or

- DALI LED Driver
- ActiveAhead Control Unit DALI
- ActiveAhead compatible sensor (in this document Active+ Sense)

From the system perspective the Control Unit and the Control Unit DALI components offer similar features. In the text of this document we refer primarily to the Control Unit. The above listed components are shown in Figure 1 above. The ActiveAhead Cable connects the Control Unit to the LED Driver. The sensor has a fixed cable which is connected to the Control Unit.

Network security

ActiveAhead security can be divided into two main parts:

- Bluetooth interface security, and
- Mesh interface security.

Bluetooth interface security

The Bluetooth low energy wireless signalling is a short-range communication method which means that the person connecting to the system over Bluetooth will need to be close to the Control Units. In addition, handshaking and shared secret are used to provide security. When communicating with e.g. the wall panel, also sequence numbering is used to increase security against repeat attacks. Furthermore, the network can be closed from mobile app connections or locked behind a PIN code by using the ActiveAhead Mobile App.

Mesh interface security

For mesh security a network ID is used. The use of a Helvar developed proprietary protocol increases security even further. The factory programmed default network ID can be changed using the ActiveAhead PC Admin App; however, this is very seldom needed.

ActiveAhead installation

ActiveAhead solution is designed to operate without specific programming and to simplify installation of luminaires. However, it is important to understand that the solution needs some time after installation to allow it to adapt to the environment. After the learning period it is advisable to review the site for possible adjustment needs. This saves unnecessary work and enables maximal benefit from the self-learning features offered by the system.

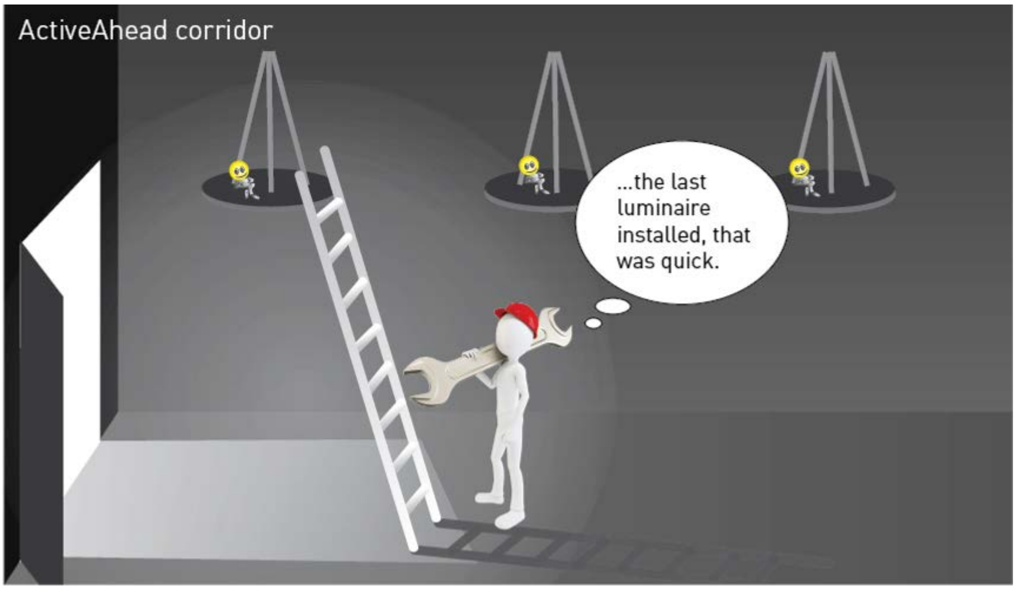
Basic check-up

After ActiveAhead luminaires have been installed to the planned positions on the site and after power has been connected the first thing to do is a simple on/off test of each luminaire. After turning the power on, each luminaire should switch on and after a period dim down and turn off. Once turned off walk below each luminaire to see that the luminaire is switched on. If the luminaire behaves differently than described here, there might be a problem and the luminaire should be changed to a new one.

NOTE: Check that the luminaires have been installed systematically and following the orientation guidelines set forth later in this document. If unusual behaviour of any luminaire is detected consult the document “ActiveAhead FAQ”.

The installation process is depicted in Figure 2 on the next two pages. The basic check-up described above can be done after switching on power to the luminaires.

STEP 1 – INSTALL LUMINAIRES



STEP 2 – SWITCH MAINS VOLTAGE ON

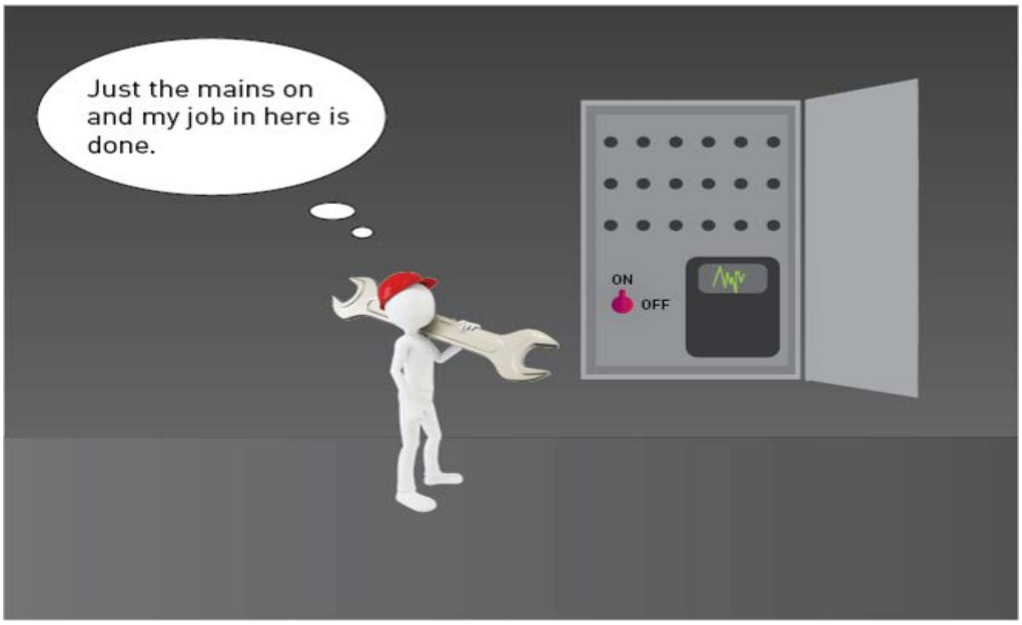


Figure 2: ActiveAhead installation – no need to configure settings (continued).

STEP 3 – BASIC CHECK-UP

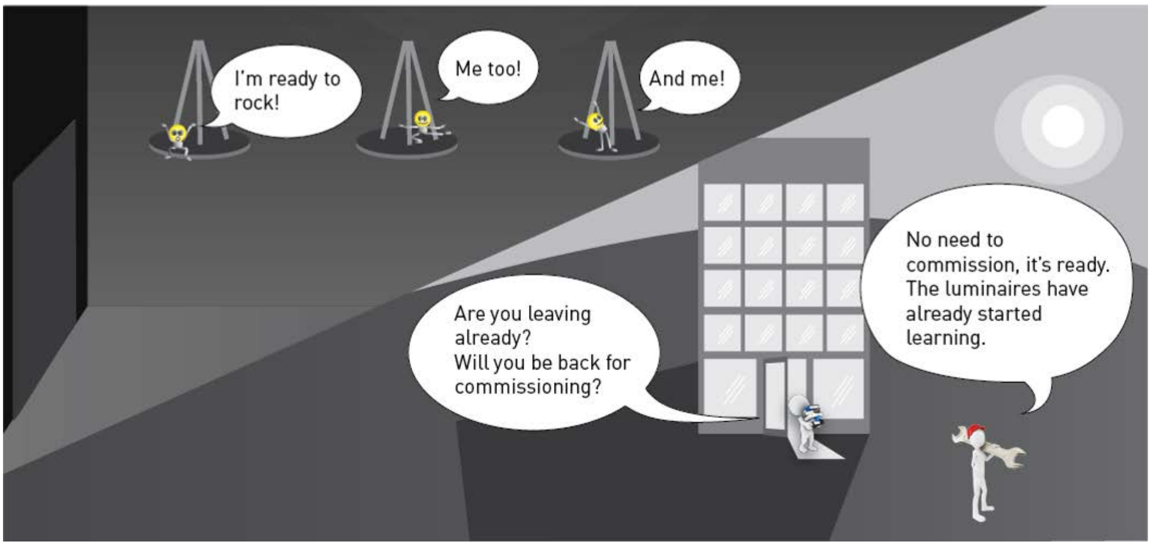


Figure 2: ActiveAhead installation – no need to configure settings (continued).

Just let it learn

ActiveAhead solution is designed to be ready for use from the start. Normally there is no need to program or adjust any settings. The default values programmed into the ActiveAhead Control Units in each luminaire will provide comfort and energy savings for typical situations. The solution will start to detect presence and movement of persons and ambient lighting levels from the start and adapts itself to the site if given enough learning time. Depending on the layout of the office, the number of persons and amount of movement learning may take from anywhere between a day to several weeks. If the site has meeting rooms requiring wall panels those need to be configured separately.

After the self-learning period - adjust only if necessary

Typically, adjustments to ActiveAhead solution parameters are not required. Before starting to adjust any parameters, it is strongly recommended to interview the persons using the site to gain insight on light levels, timeouts, daylight harvesting and potential grouping needs. After interviewing users, the results should be analysed and only after that decisions should be made regarding which luminaires and parameters require adjustments. The list of all user adjustable parameters with default values and ranges are listed in APPENDIX – System parameter default values.

Further details on how to adjust the parameters are explained in the ActiveAhead Mobile App User Guide.

Stored learnings

Each Control Unit will store learnings affecting the unit's behaviour to a non-volatile memory. Thus, those learnings aren't removed or changed even if power is turned off and back on. Thus, in a stable system, it would be extremely difficult for any user of the space to notice the effect of turning off and on the units. During the initial learning period, turning off and on may make the learning slower due to the potential loss of some data which would otherwise lead into saved learnings.

Luminaire operation

The following subsections explain how ActiveAhead luminaires work when used as standalone luminaires or as part of larger ActiveAhead systems. Although possible ActiveAhead luminaires would typically not be used in a stand-alone configuration but for this discussion it is worthwhile to first look at how a standalone luminaire works and which parameters are used to control the light level of the luminaire.

ActiveAhead luminaires most typically used as part of larger ActiveAhead lighting systems in which the operation and behaviour of any single ActiveAhead luminaire depends on both stand-alone functionality of the individual luminaire and learned behaviour based on notifications received from other luminaires. The following three cases are used to help clarify ActiveAhead luminaire operation in more detail.

Case 1: Stand-alone ActiveAhead luminaire

All ActiveAhead luminaires contain two sensors - the ambient light sensor and the PIR sensor. These two sensors in effect form the Active+ Sense sensor. The measured ambient light level from the light sensor and the detected occupancy state from the PIR sensor determine the on/off state and the light output level of the luminaire. The user can adjust the lighting level to which the luminaire switches on to, the timeouts for on and off switching, ramping speed for on and off switching and setting the daylight harvesting function on or off. These programmable settings are set with a mobile device such as a smart phone or tablet which has the ActiveAhead Mobile App installed. If there are no other ActiveAhead luminaires within range of the Bluetooth low energy module located inside the ActiveAhead Control Unit the above listed are the only inputs effecting the operation of the luminaire.

The inputs and outputs concerning a single ActiveAhead luminaire are listed below:

INPUTS

- User programmable parameters
  - light levels
  - timeouts
  - daylight harvesting
- Movement detection data from the PIR occupancy sensor

- Ambient light level data from the light sensor

OUTPUT

- Light level to control the luminaires LED elements

Case 2: Two or more ActiveAhead luminaires

If any two ActiveAhead luminaires are within the Bluetooth low energy wireless range of the built-in Control Unit the luminaires will establish a mesh network and start to send data to each other. Notifications are sent containing data about detected movements and the RSSI (Received Signal Strength Indicator) value of the received messages, which is used to determine the distance to the sender.

The receiving luminaire measures the time from a movement notification to the time it detects the movement itself and uses a patented algorithm to determine whether the received notification and the detected movement are related to the same movement and whether to “learn” from the data. The Control Unit stores such hits and when the same pattern has been detected often enough, the Control Unit will store the learning as a follow strength value linked to the neighbour. The light level of the luminaire is then set based on the follow strength value whenever a movement notification is received from the neighbour.

If on the other hand the light level of a luminaire is already set to a higher level than the light level that would be set based on the follow strength value or if the light level of the luminaire was set earlier by using a control such as a wall panel the light level will not be changed. Each luminaire acts independently in this respect. The inputs and outputs between any two luminaires within wireless range of each other are listed below:

INPUTS

- User programmable parameters
  - light levels
  - timeouts
  - daylight harvesting
- Movement detection data
  - The luminaire’s own occupancy sensor (PIR)
  - Notification messages from the neighbouring luminaires occupancy sensor (PIR) received as notifications from the mesh network
- Ambient light level data from the light sensor

OUTPUTS

- Light level to control the luminaires LED elements
- Movement detection notifications sent to the mesh network

If the number of luminaires is increased the only difference to the above is that the Control Units of luminaires will also utilize a hop count value which is embedded in the received notifications. This hop count value is used to further determine the distance from the receiver node to the node which is the originator of the notification.

NOTE! A Control Unit cannot learn efficiently if there are too many movement notifications being received from the neighbouring Control Units as it becomes more difficult to determine which detections are caused by the same movement. Learning will continue once the amount of notifications from neighbouring Control Units again becomes smaller. The inputs and outputs concerning a multi luminaire system are listed below.

Case 3: Systems with wall panels

In certain applications such as offices with meeting rooms a method to enable manual control of lights is needed and this is accomplished by using ActiveAhead wall panels. First, a group of luminaires such as those located in the same meeting room are programmed to belong to the group. This process is called grouping. The wall panel contains a set of scenes which are collections of light levels suitable for certain situations (presentation, negotiation, party, cleaning etc).

For example, in a typical presentation mode scene, the near luminaire nearest to the presentation screen are switched off, the next row of lights is adjusted to 25 % light level and the rest of the lights in the room to are 75 % or 100 % of light level depending on the light output of the luminaires.

When a wall panel button is pressed, the Control Units of the luminaires configured into the same group and controlled by the wall panel will go to the configured light level despite the light level they were at prior to the button press. The lights will remain on that light level until there is no movement detected by the group after the set timeout has passed. The group created for a wall panel is typically used for having the lights on at a wanted light level whenever any of the group members detect movement.

Nevertheless, each Control Unit will continuously learn from its neighbours and might learn to follow Control Units outside of the wall panel group. In this case, for example a luminaire in an empty meeting room could be switched on whenever a person walks down the corridor next to the meeting room to offer comfort for the person possibly entering the room.

When Absence Detection mode is on, learning will not visible because the luminaires will only go on when a wall panel button is pressed. Nevertheless, the learning will continue to happen on the background and will be seen when the Absence Detection mode is disabled.

A figure with a floor plan clarifies the terminology and the relationship of the listed terms (see Figure 3 on next page).

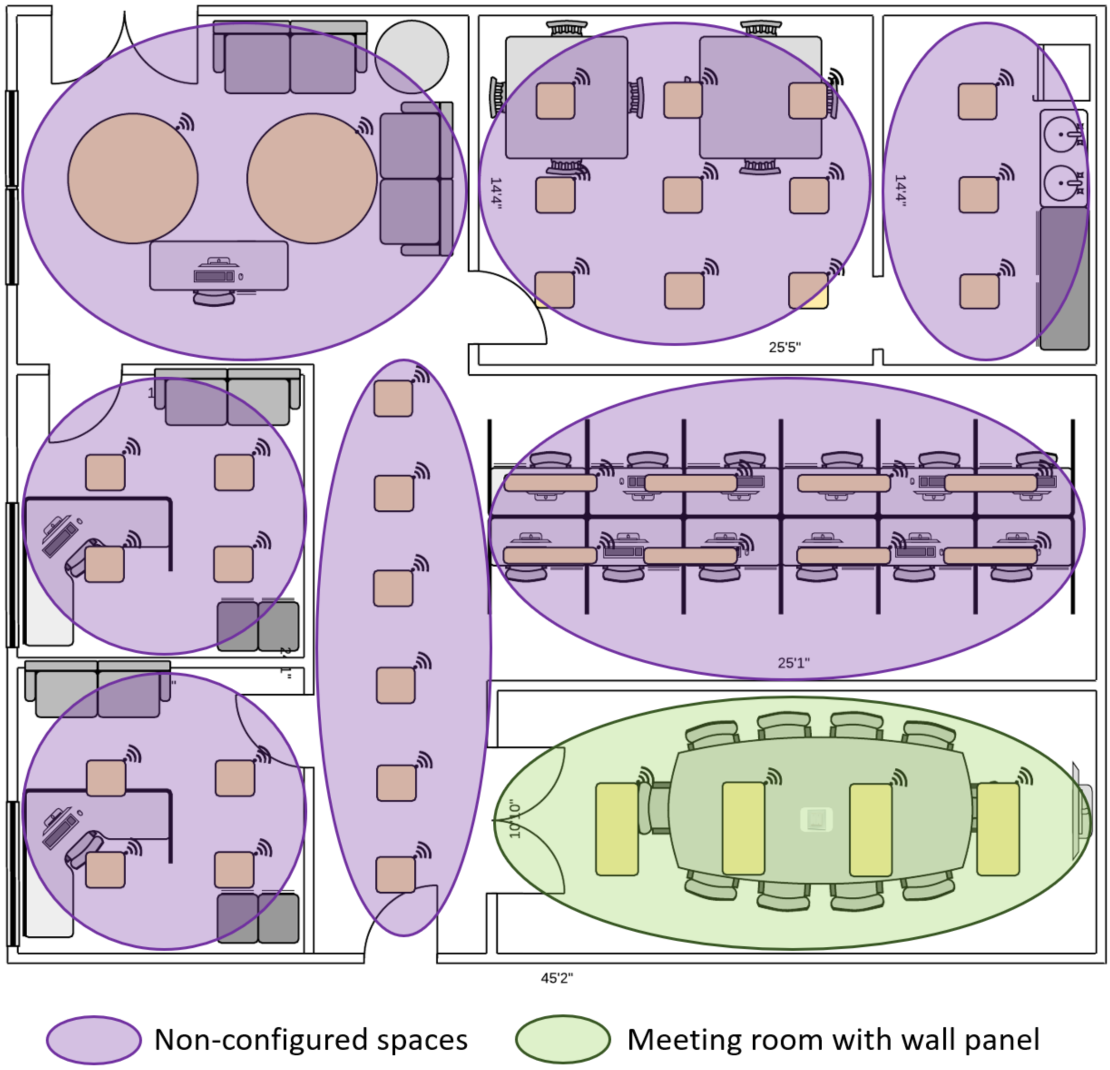


Figure 3: An example floor plan with several different types of spaces.

In the figure above, we can see an example floor plan with several spaces, walls, windows with natural light input from outside the building, corridors and some rooms as well as a meeting room with a wall panel. In this example the meeting room would have configured scenes while the rest of the site would could work in self-learning mode.

The inputs and output are listed below:

INPUTS

- Set parameters
  - Light levels
  - timeouts
  - daylight harvesting
- Movement detections
  - The luminaire's own presence sensor

    - Neighbouring luminaires’ presence sensor
- Light sensor value
- Wall panel button press events

ActiveAhead self-learning principles

ActiveAhead solution is based on an artificial intelligence algorithm which collects and analyses movement (presence) and ambient light levels within range of the sensors included in each ActiveAhead luminaire. After enough movement data has been collected for the algorithm to identify common paths, predictions can be made to dim the light according to the movement detections from the neighbours. The Control Unit also considers parameters set at the manufacturing or potentially changed by the user configuring the system.

Learning and unlearning movement patterns

Luminaires learn nearby nodes individually. On system level this can be thought of as movement patterns in space but the learning in individual units is not concerned with learning actual paths. An individual unit updates the follow strength of another node based on the number and frequency of movements it considers to be originated from the neighbouring Control Unit. Unlearning is related to the changes in the amount and frequency of such movement detections from the neighbouring node.

The unlearning period is intentionally longer than the learning period because in this way the system can be sure that the change is permanent. If the new movement is clear learning will occur quicker. Figure 4 below shows the principle idea of learning and unlearning.

NOTE: Each luminaire learns movement paths through data exchange with its neighbours. It is not possible to copy learned data to another luminaire.

The above described principle is described in the cartoon starting on the following page, in Figure 4 (learning movement paths), Figure 5 (adapting to structural changes) and Figure 6 (energy saving).

LEARNING MOVEMENT PATHS

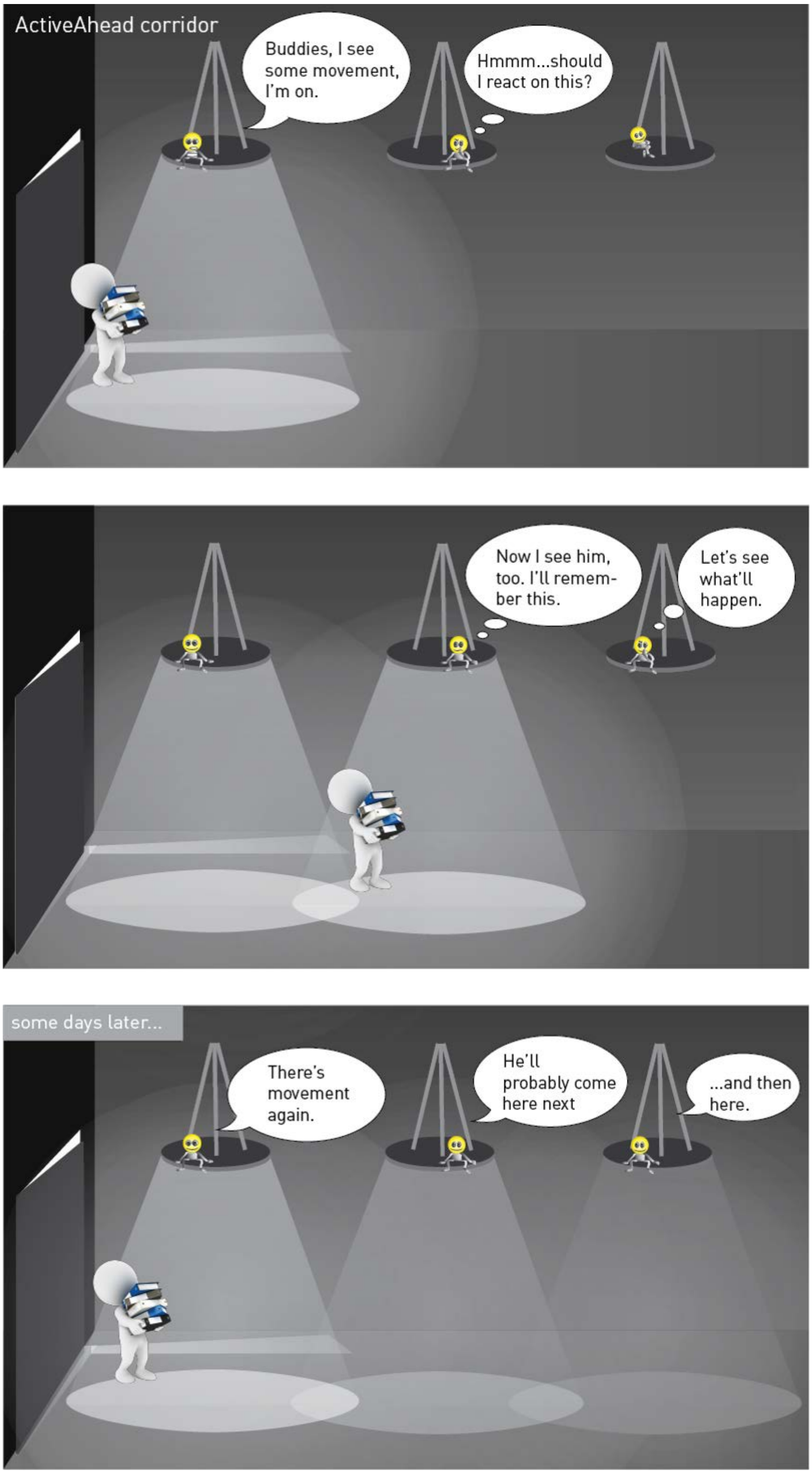


Figure 4: ActiveAhead learning – learning movement paths.

ADAPTING TO STRUCTURAL CHANGES

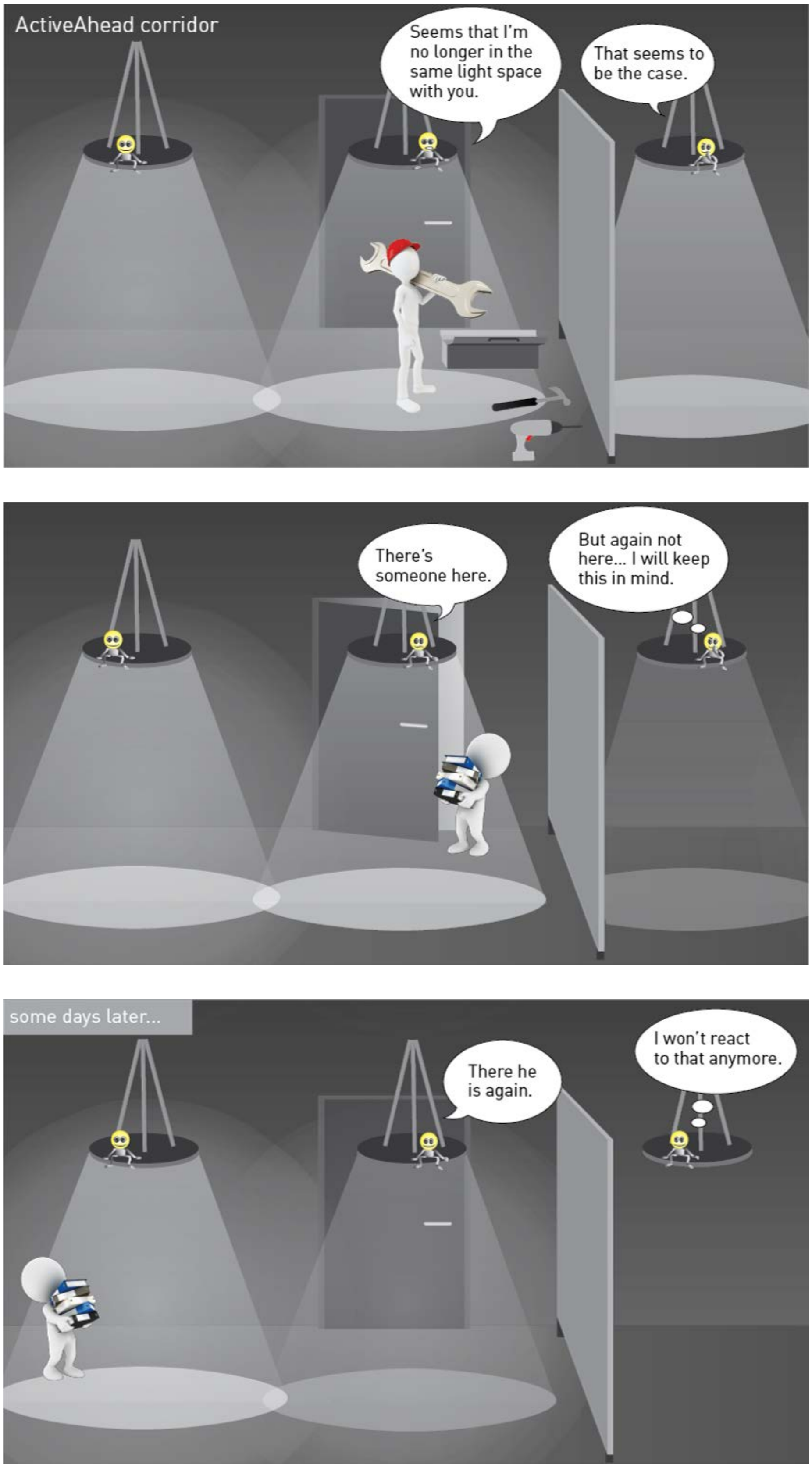


Figure 5: ActiveAhead learning – adapting to structural changes.

ENERGY SAVING

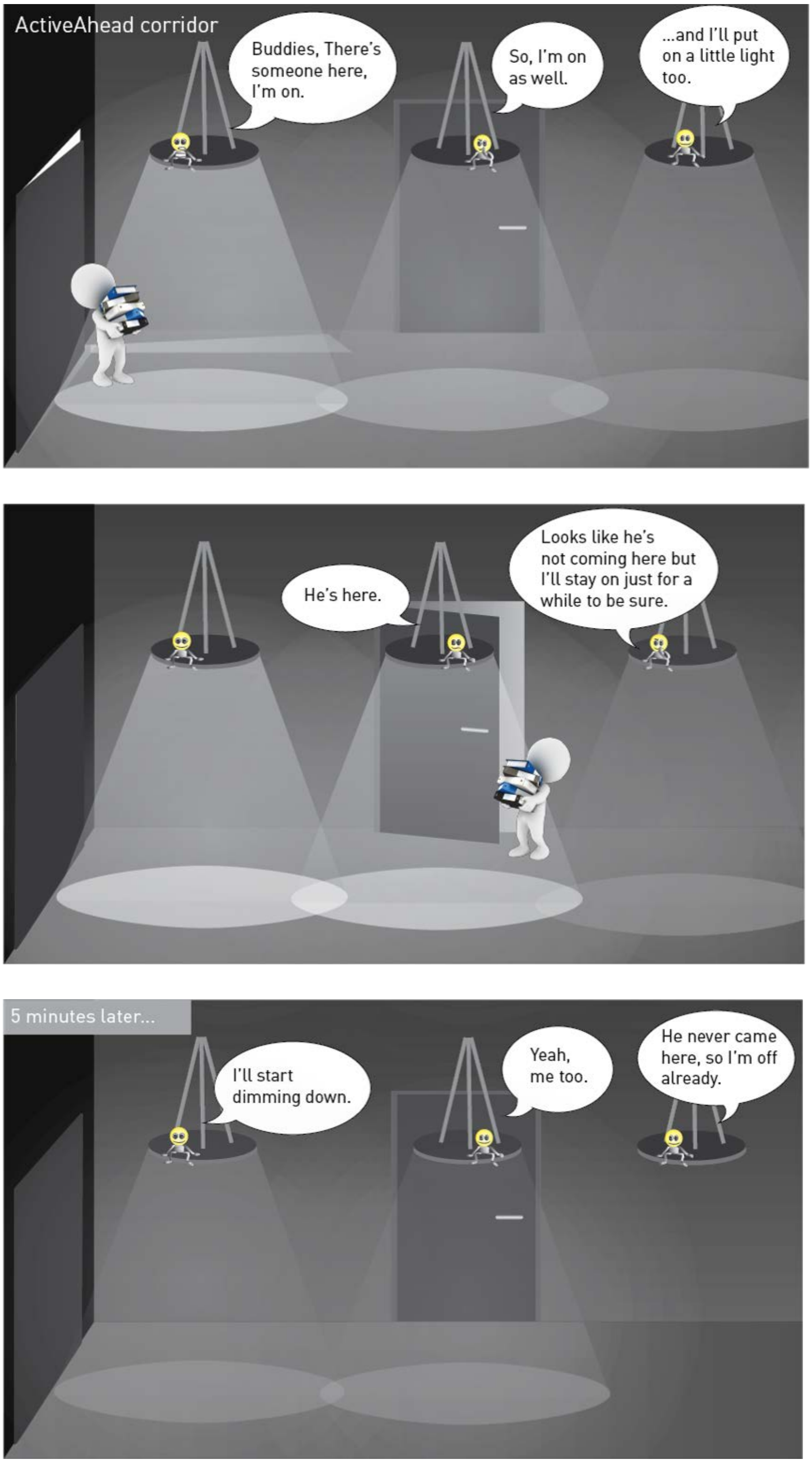


Figure 6: ActiveAhead learning – energy saving.

Learning examples

The ActiveAhead algorithm interprets the data it receives in different ways depending on the actual movement in the space and placement of the luminaires (or their sensors) in relation to the physical layout of the site. In addition, each luminaire follows the hierarchy of the parameters regardless of the amount of movement. For example, each luminaire will switch on to give light if the PIR sensor of the luminaire detects a presence of a person near the luminaire. The following five figures present commonly seen office layouts with some comments on the behaviour of the luminaires.

Straight long corridor

The example in Figure 7 below shows a long corridor with ActiveAhead luminaires installed on the ceiling of the corridor. As a person enters the corridor the first luminaire's PIR sensor detects the person and the luminaire is switched on. At the same time the Control Unit of the luminaire sends a message through the Bluetooth wireless connection into the mesh network. If the corridor has been used for a while the luminaires have had time to learn that persons who enter the corridor typically exit the corridor from the other end. Thus, the luminaires in the corridor know that they will need to switch on. The artificial intelligence in each of the Control Units calculates which other Control Units the Control Unit in question should follow. The system level outcome of the learnings will make the lights switch on ahead of the person's movement. This improves safety among other things. After the person has walked past a luminaire and the occupancy timeout has passed without new movement detections, the luminaire will dim to a lower light level and after the transition timeout the luminaire will be turned off completely.

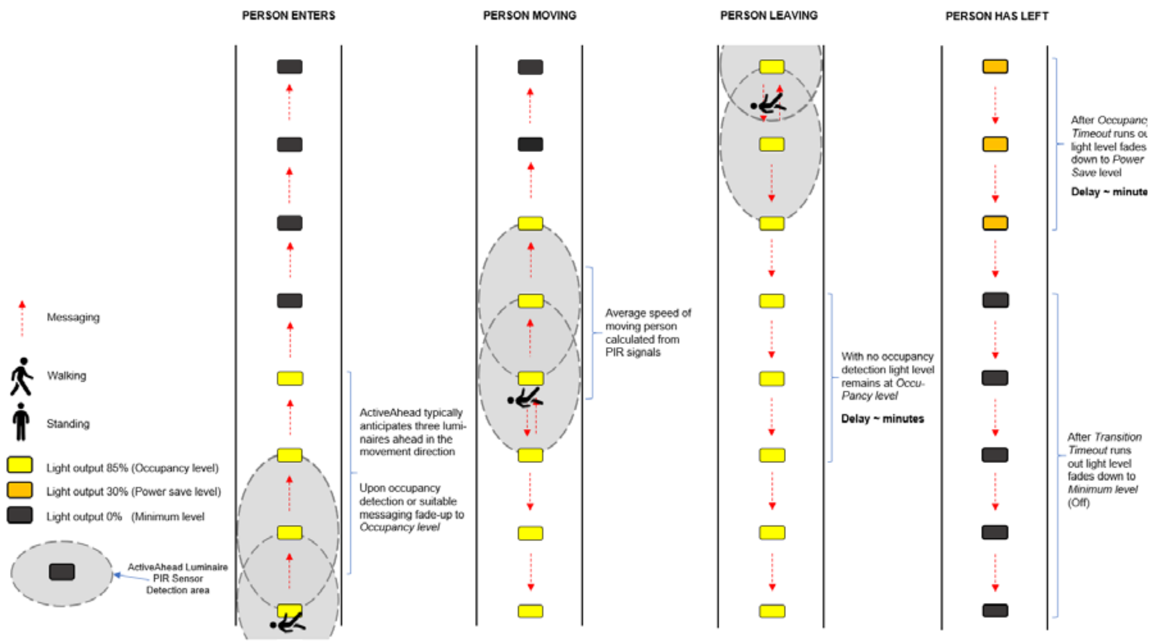


Figure 7: Straight long corridor

Straight long ending corridor with a T-junction

A slightly more complex situation arises when the corridor ends in a T-junction as shown in Figure 8 below. Usually one of the directions from the T-junction is used more than the other. On system level the outcome of the artificial intelligence of the ActiveAhead Control Units determines the popularity of the paths taken by people. It can therefore favour the most likely route by switching on luminaires further along the more popular path in front of the walking person.

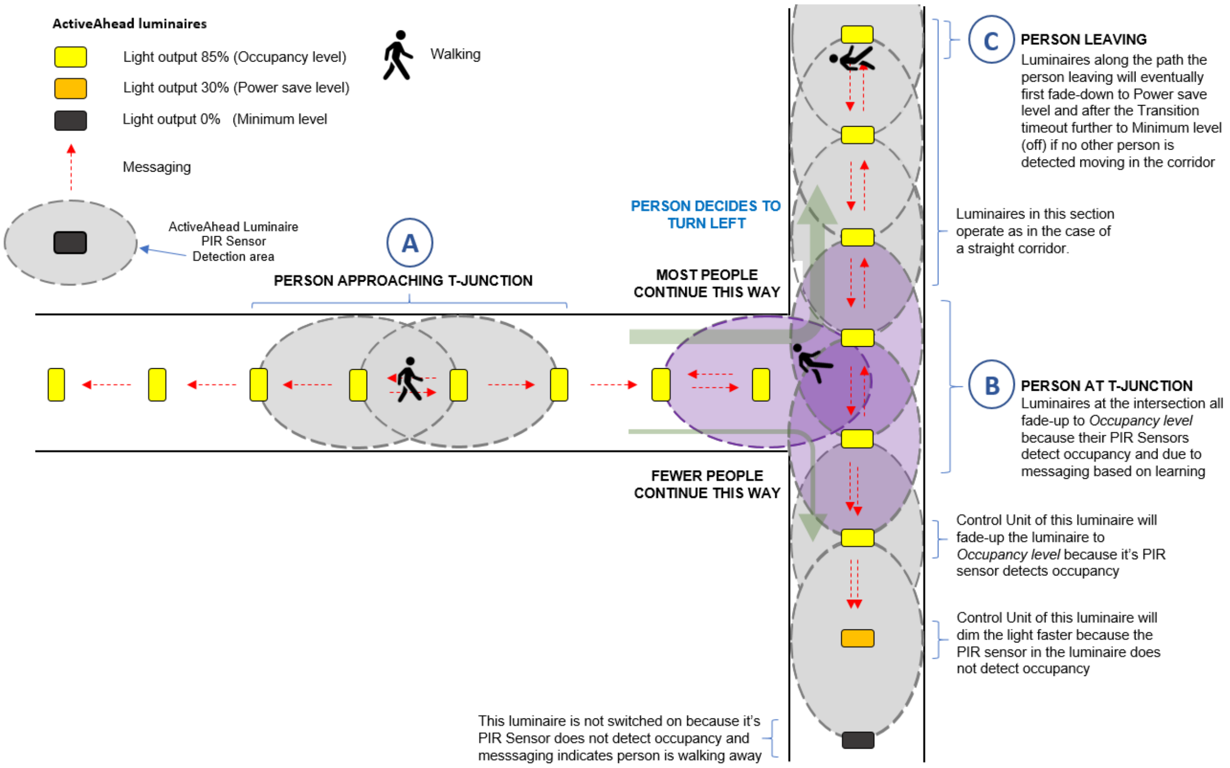


Figure 8: Straight long ending corridor with two 90° branches (T branch)

Straight long corridor with a door open into a meeting room

What happens if there is a door to another room such as a meeting room somewhere along the corridor? Each luminaire is controlled by the built-in PIR sensor. If any luminaire detects the presence of a person the light will be turned on.

With the above understanding we can now look at Figure 9 below. Here the situation is the same as in Figure 7 but with the following additional behaviour. If people enter the room often, the Control Units in the room will learn to follow the Control Units in the corridor. In such cases, one or multiple luminaires will switch on when a person passes the room. However, the lights in the room will not change their light level in case a wall panel scene has been recalled for the Control Units in the room. The luminaires belonging to a group can be grouped to enable easier and more effective control of several luminaires. When the presentation is over and people have left the seminar room, an exit delay function is used to ensure that the people have left the room. After the exit delay the Control Units in the room will return to the normal ActiveAhead mode unless the room has been set to work in absence detection mode. In absence detection mode the luminaires will not show the learnings at all while the learnings do continue to happen on the background. Note that keeping the room door open may mean that the first sensor in the room will detect at least some of the movements on the corridor and thus it will follow the corridor Control Units stronger than it otherwise would.

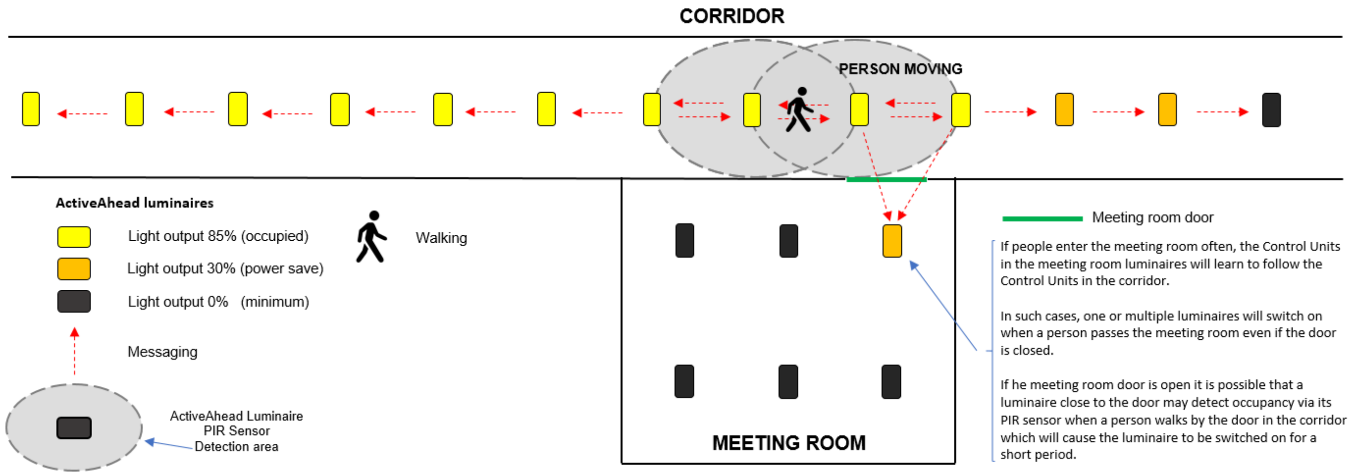


Figure 9: Straight long corridor with a door into a meeting room

Workstations in an open office space

The term workstation here refers to a desk by which a person works. Typically, the person stays stationary on the same spot for tens of minutes at a time. At times the person may not move much or the small movement is not visible to the PIR sensor. The ActiveAhead system will try to detect these kinds of cases and extend the *Occupancy timeout* for the duration of the ongoing session to avoid falsely dimming down the light while the person would still be under the light. In the following example (Figure 10) there are plenty of workstations in an open plan office layout. There is also a corridor like walking path going through the open plan office.

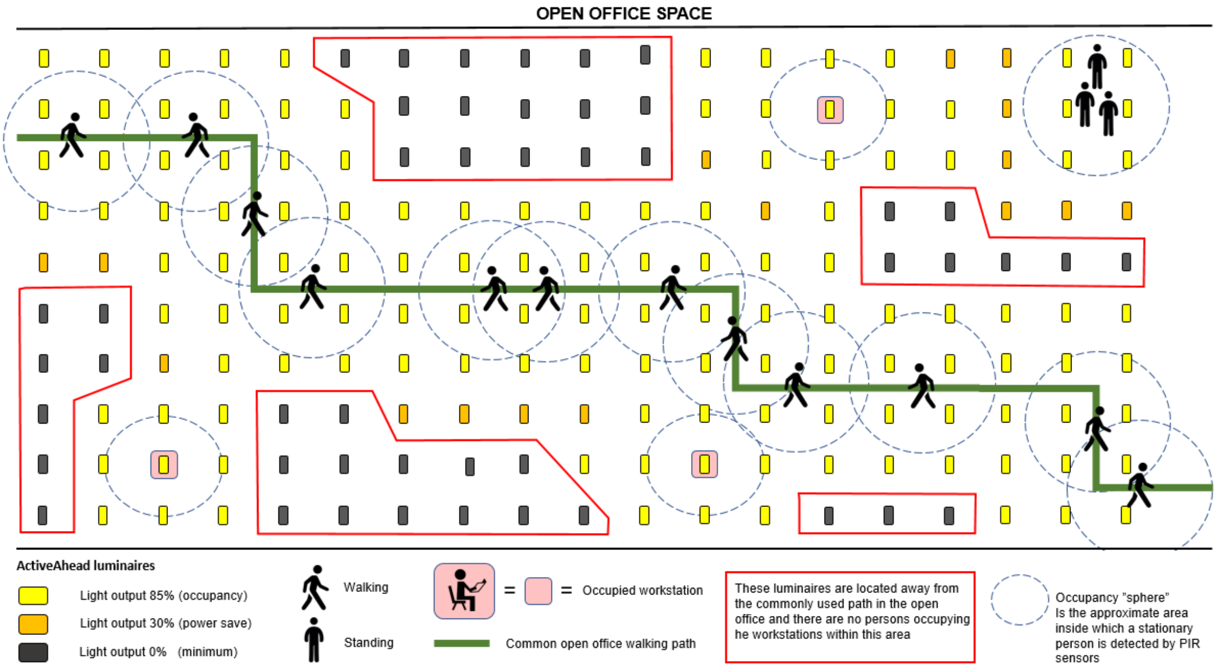


Figure 10: Workstation in an open office space

Effect of walking speed on predictive switching of luminaires

ActiveAhead Control Units calculate from the received movement detection messages the average time it takes for the movement to reach its detection area. This calculation is done separately for each nearby Control Units sending the messages. The system level outcome works like a system which calculates the average speed of the moving persons or objects to determine the successive switch-on timing of neighbouring luminaires. The purpose of this is to ensure that the system adapts to different applications, e.g. open plan office areas, corridors, stairways or parking garages.

Wall panels and grouping in practice

Typical office applications consist of several different types of spaces including meeting rooms. ActiveAhead system solution includes components and features to enable building efficient and user-friendly lighting control solutions without comprising any of the energy saving advantages of the ActiveAhead solution.

Meeting rooms typically have a group of luminaires which need to be controlled as a group by an easy to use wall panel. The grouping feature and the ActiveAhead wireless wall panel make this possible.

The first thing to do is to configure the wall panel and then define how the luminaires in the room should act when a button on the wall panel is pressed.

To understand how grouping and the wall panel are used to override other ActiveAhead control features consider Figure 12 which shows a typical example of a simple meeting room.

After the configuration has been done the meeting room can be dimmed easily by selecting from the wall panel a scene which suits the presentation (lights are turned off or dimmed closest to the presentation screen, 25% on second row and 75% on the last row).

If there are people in the meeting room which move the PIR sensors in the ActiveAhead luminaires detect occupancy which in turn prevents the luminaires from changing state. Even if the door to the corridor is open and people walk in the corridor walking over the PIR detection area of the luminaire closest to the door and inside the meeting room the luminaire does not react in any way but maintains the settings defined by the selected scene.

After the presentation the people will leave the room. Once the exit delay is run luminaires will move into their normal ActiveAhead state.

An example of a meeting room is shown in Figure 11 below.

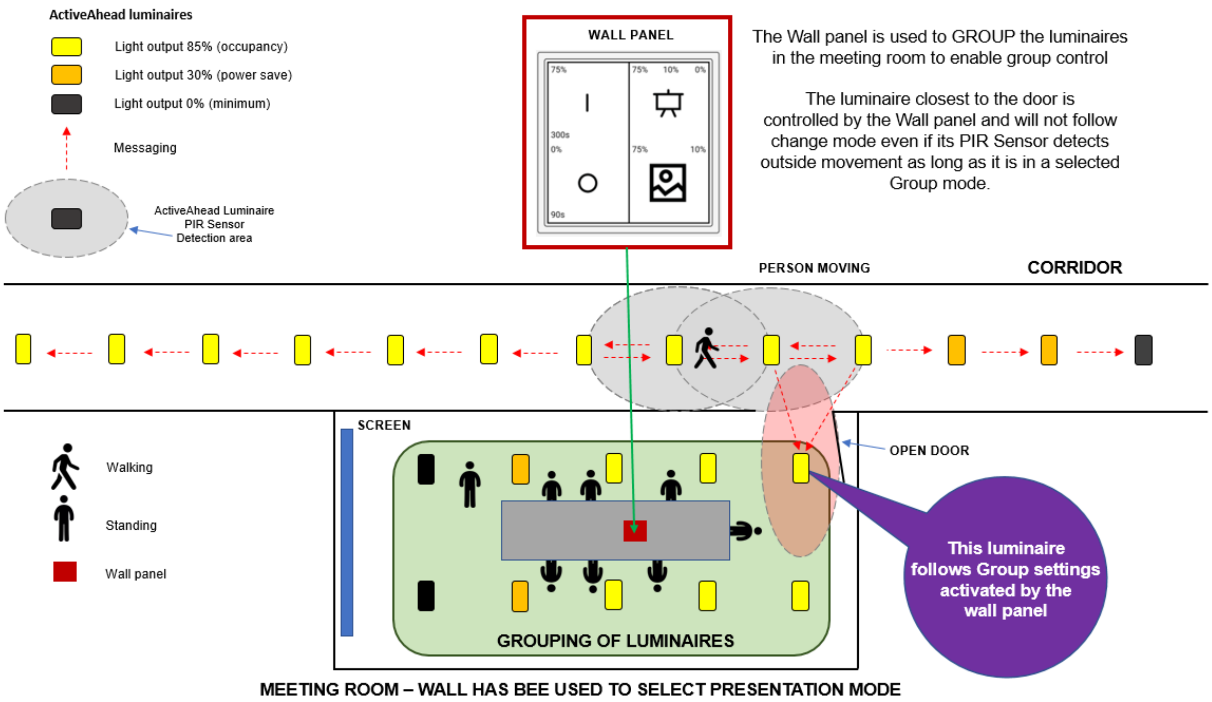


Figure 11: A simple meeting room.

Learning period

The length of the initial learning period cannot be known beforehand. It will depend on the space layout of the site and even more so on the movement patterns and on the amount of movement in the space. The fastest learning is achieved when there are clear movement patterns in the space with little or no other disturbing movement. In case there is a lot of movement, it becomes impossible for the luminaires to determine the actual movement patterns and in such cases the luminaires will ignore such random movements as “noise”. However, despite the “noise” produced by other nearby Control Units, a Control Unit may still learn from the other neighbours which have been silent for a while before a new movement detection. In an office environment, the luminaires will most likely learn the first patterns within a day assuming there is enough systematic movement in the space.

Vacations and other abnormal periods

To prevent the system from unlearning movement patterns during longer exceptional time periods such as holidays, during which most or all persons on the site are absent for many days and even weeks, the luminaires maintain all learning related data. Thus, the system will function in the same way as it did before the vacation period started.

In case there is some different than normal movement in the space, some of the luminaires may learn new movement patterns and these patterns may strengthen already learned patterns. On the other hand, some earlier learnings might get weaker or even be fully lost. However, once people are back from their vacation, common movement patterns will be relearned and strengthened. In other words, the system adapts itself to changes in the movement patterns.

Importance of correct luminaire positioning

The ActiveAhead solution senses movement below the PIR (Passive Infrared) sensor and ambient light levels with a light sensor. These two sensors are invariably part of each ActiveAhead luminaire. To optimize the learning capability of the system the luminaires (or rather their sensors) should be installed and oriented correctly in addition to being placed correctly on the luminaire. The sensor unit is typically located at one edge of the luminaire enclosure. Optimally all luminaires should be installed in the “same way”, meaning that the sensor side should always point in the same direction, especially if the luminaires are in the same row.

In a corridor the luminaires should be oriented so that they can detect the movements on the wanted area. Note that a sensor on a corridor may detect movement also outside the corridor, for example in an open plan office area or in a room depending on the layout of the space. In addition to the orientation of linear luminaires in corridors it is recommended that the Active+ Sensor is installed on the luminaire enclosure as indicated in
Figure 12.

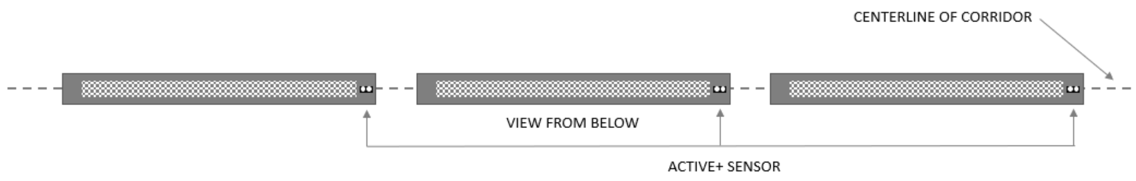


Figure 12: ActiveAhead linear luminaire sensor orientation in corridors.

These movement detections affect the learnings which the connected Control Unit as well as the neighbouring Control Units gain. Thus, from the system perspective, the luminaire on the corridor may be more like a workstation or room luminaire. For office spaces with windows the sensor should be installed pointing away from the window. This is to prevent strong sunshine from saturating the light sensor or from affecting the sensitivity of the light sensor. Also, the wall below the window may create shadows which would block the daylight from reaching the light sensor.

Note that for symmetrical luminaires the same principle applies regarding sensor orientation although with symmetrical luminaires the sensor can often be placed directly on the centreline of the corridor anyway.

If luminaires (or their sensors) are located too close to a window the wall below the window may create a shadow on the coverage area of the light sensor. In such cases the sensor would not see the daylight whereas neighbouring luminaire sensors might. The result would then be that the luminaire with the shadowed sensor might be on while the other luminaires might be completely off or dimmed to the minimum daylight dimming level because the other sensors see enough daylight.

Recommended and not recommended examples of sensors located on luminaires next to a window wall are shown in Figure 13.

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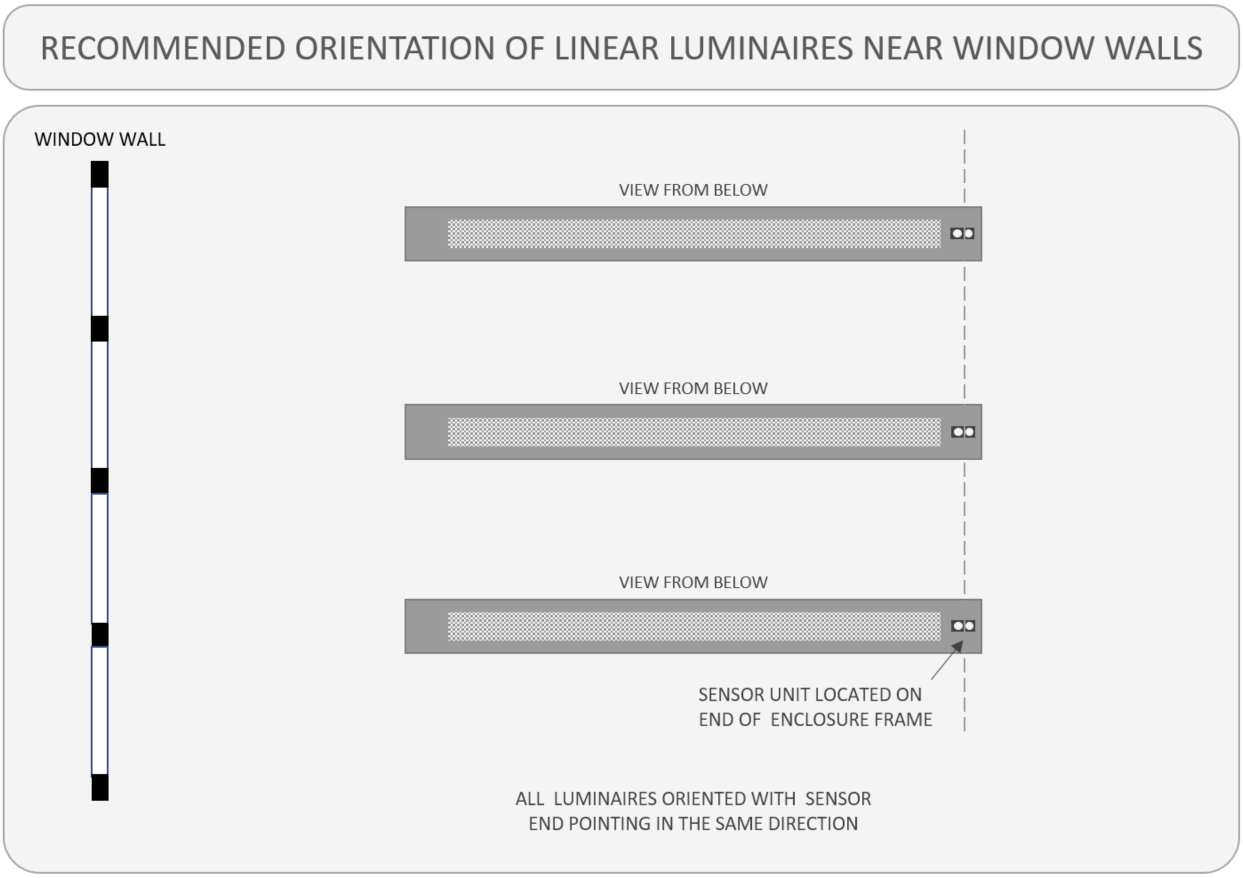

Figure 13: Orienting linear luminaires near window walls.

The basic installation rule is that linear luminaires with the sensor at the end of the luminaire enclosure should be installed with the sensor ends of each luminaire pointing in the same direction for luminaires in the same physical space. It is recommended that this general rule is followed throughout the site.

For luminaires closest to blank walls or corridor walls with windows the sensor ends should be pointing away from the wall. Figure 14 shows these principles.

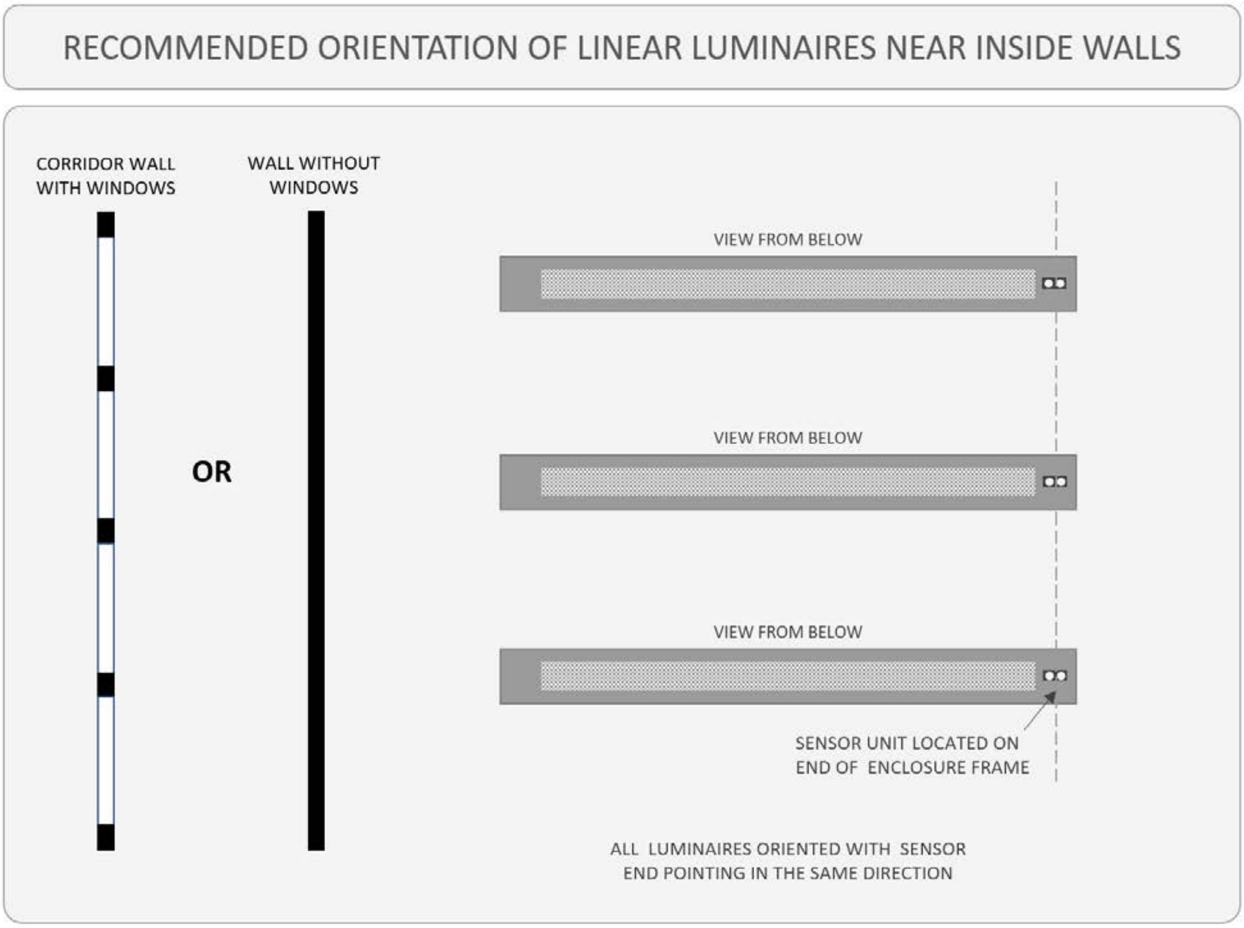

Figure 14: Orienting linear luminaires near inside walls.

Summary

- The sensors on each luminaire should be systematically oriented to give a balanced learning output
    - for window walls place luminaires so that their sensors are located at the end furthest away from the windows to avoid shadows caused by the wall below the window and to make it less likely for strong sunshine to saturate the light sensor of affect its sensitivity.
- Luminaires should be evenly spaced to each other to achieve a consistent overall light level.
- The sensors in each luminaire need to be able to detect the wanted movement
    - do not place sensors directly above shelves and other tall furniture etc.
    - do not place sensors close to walls.

Evidence of self-learning

Artificial intelligence based lighting control systems measure certain parameters from their environment which enable the system to maintain desired lighting levels during different conditions. Since applications and environments differ it may not always be self-apparent that the ActiveAhead has self-learned to adapt the behaviour of the lighting control system to local site characteristics. However, there are some easy to see signs which indicate that the system has and is self-learning. It is also possible to actively check what kind of paths the system has detected.

During initial learning period

Immediately after commissioning the system has not yet received enough statistical data on the movement paths for it to be able to modify its behaviour. The number and placement of individual luminaires, the number of people walking about the office, and the randomness of such movement will have an impact on the learning period which may be anything between a day or two to several weeks.

The most obvious sign that self-learning is happening can be seen typically in long corridors where a linear row of luminaires will start to "chain up". If there has not been movement in a while in the corridor and you start to walk along the corridor luminaires ahead of you will start switching on. The luminaires above you will produce higher light levels than those located a bit further away from your current location. Luminaires furthest away will either remain switched off or are on at a very low light level.

The luminaires will light up one by one as you walk in the corridor. When you come to a corridor branch or crossroads the first one or two luminaires in the other possible directions might also be switched on but if you continue straight on these luminaires will be switched off after a relatively short delay.

After the initial learning period

It is possible to check the learned movement patterns. First set the luminaire timeout values shorter to make them switch off faster. Then wait for all the corridor luminaires to switch off and then walk along the corridor as you would when moving about in the office normally. The luminaires in the corridor should switch on in front of you as you move forward along the route.

After a certain time depending on the overall size of the system, the layout of the site and the movement patterns created by the persons moving in the site, the system will be rather stable and new learnings are less likely to happen until there are changes in the movement patterns in the space. ActiveAhead solution does not support a walk test using the mobile app. Thus, the easiest way to check what the system has learned is to change the timeouts to be short for the duration of the test. However, the best feedback on the system behaviour can be received from the daily users of the site.

System parameters and priority

This section describes the system parameters and their priority, i.e. how the ActiveAhead solution allows these parameters to affect the light levels.

Priority levels

ActiveAhead solution prioritises inputs to enable logical operation and configuration in different applications. Typically, the priority order from highest to lowest is:

- WALL PANEL
- LUMINAIRE'S OWN MOVEMENT DETECTION
- GROUPING
- LEARNING

In simple terms, the system will follow the input which gives the highest light level; except for the wall panel, which overrides the other inputs. E.g., group member light level can be set to the same level with occupancy light level, which is typically the case in a meeting room, or to a low level, which might be the case on a corridor. In case of multiple groups, all of them are considered separately on individual Control Unit level. Thus, members of one group might be on different light levels depending on their active states.

Input parameters

An ActiveAhead luminaire by itself measures directly only two environmental parameters (called here directly measured parameters). The rest of the logical deductions and calculations (called here indirectly derived parameters) are based on the directly measured parameters. To complicate the matters a bit more in a system the luminaires exchange information regarding detected movement and the exchanged data enables further timing related calculations and decisions. Parameters in both groups are listed in Table 1 and Table 2 on next page.

Directly measured parameters

Parameter	Comments
Light	Indicates total reflected light from below luminaire e.g. floor Applications: - minimizing energy consumption through daylight harvesting - producing desired light level in different conditions - compensation for ageing of LED elements in luminaire
Movement	Indicates movement of person or persons below the luminaire Applications: - switching on (comfort) - dimming down and off (energy saving)

Table 1: Directly measured parameters in ActiveAhead solution.

Indirectly derived parameters

Parameter	Comments
Neighbours	Nearby Control Units that are considered potentially relevant for learning
Follow Strength	Table of neighbours and the corresponding follow strength
Time	Time between received movement detection from a neighbour and the luminaire’s own PIR movement detection
Distance	Message hop count from neighbours
RSSI	Average Received Signal Strength Indicator from the neighbors

Table 2: Indirectly derived parameters in ActiveAhead solution.

Output parameters

The ActiveAhead solution controls the light with the help of several different parameters. These parameters are listed in Table 3 below.

Output parameters

Parameter	Comments
Light levels	Define to which light level the LED Driver is driven. Adjusted on basis of set light level parameters and the **Follow Strength** value.
Timeouts	Defines the timeouts and fade times. Adjusted on basis of set timeout parameters and whether state was triggered by luminaire's own movement detection or that of the neighbours.
Occupied timeout	Occupied timeout increased temporarily (up to 10 min) when continuous triggering is detected in occupied state. Helps to prevent undesirable dimming when person may still be under the light.
Daylight Target Value	See a detailed explanation on Daylight harvesting after this table. Note: Default occupied light level value is set to 85 % to allow light level increase over time to compensate for LED element ageing effects.

Table 3: Output parameters in ActiveAhead solution.

Occupied timeout extension explained

Occupied timeout is increased by the Control Unit automatically temporarily (up to 10 min) when continuous triggering is detected in occupied state. This is done to help to prevent undesirable dimming when a person may still be under the luminaire, which may happen in static working environments with PIR sensing technology. Extension is session based which means that the Control Unit starts to observe the movement trigger patterns when it enters the occupied state, extends the timeout temporarily when it considers it to be necessary and will clear the extension when the Control Unit exits the occupied state.

Figure 15 on the following page depicts the Occupied timeout extension.

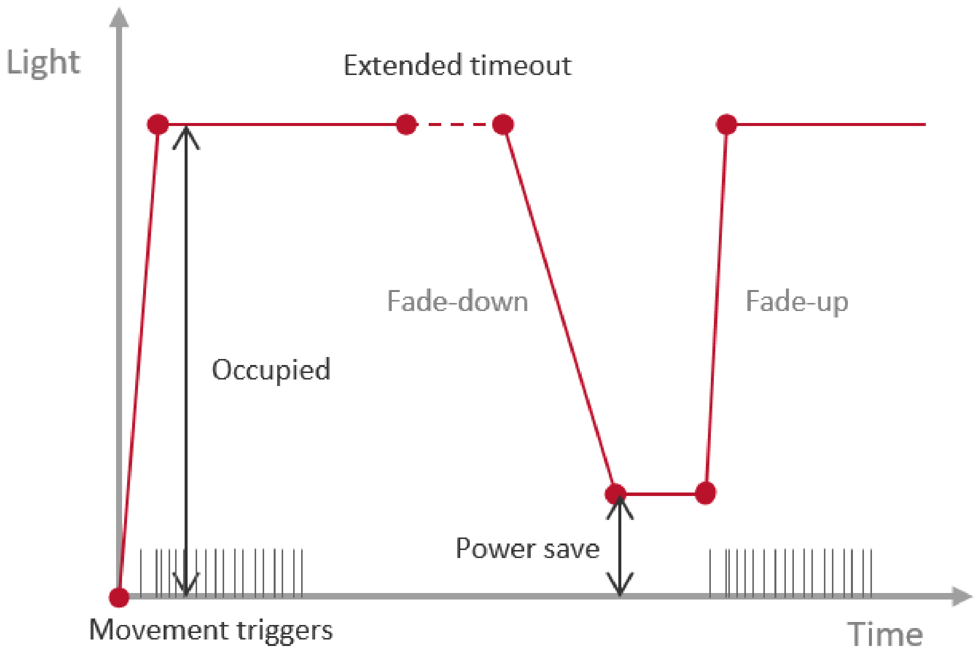

Figure 15: Occupancy timeout extension is used to preserve the current scene or state

Daylight harvesting explained

Daylight harvesting is turned on by default. When a Control Unit is powered on, it will start calculating the target value for daylight harvesting. It will do this based on the values it receives from the light sensor while the Control Unit is on the occupied state. Calculating the target value over a longer period allows the Control Unit to take out the daylight from the measured value. The target value is linked to the default light level.

When the occupied light level parameter is changed, a new target value needs to be measured. This is done by taking a snapshot at the time of setting the new parameter. The logic is that the person configuring the system will measure the light on the wanted surfaces using a light meter. Once the wanted light level is found, that is set for the network, group or individual luminaires. Consequently, the system will store the measured light value right after the new parameter is set instead of measuring it over a longer period. Therefore, it is mandatory to set the light levels only when no daylight is present to avoid daylight affecting the measured target value.

There is threshold around the daylight target value which is used to avoid the luminaire from constantly dimming up or down. The Control Units have an algorithm by which they try to further minimize that unwanted effect.

The above is depicted in graphical format in Figure 16 on next page.

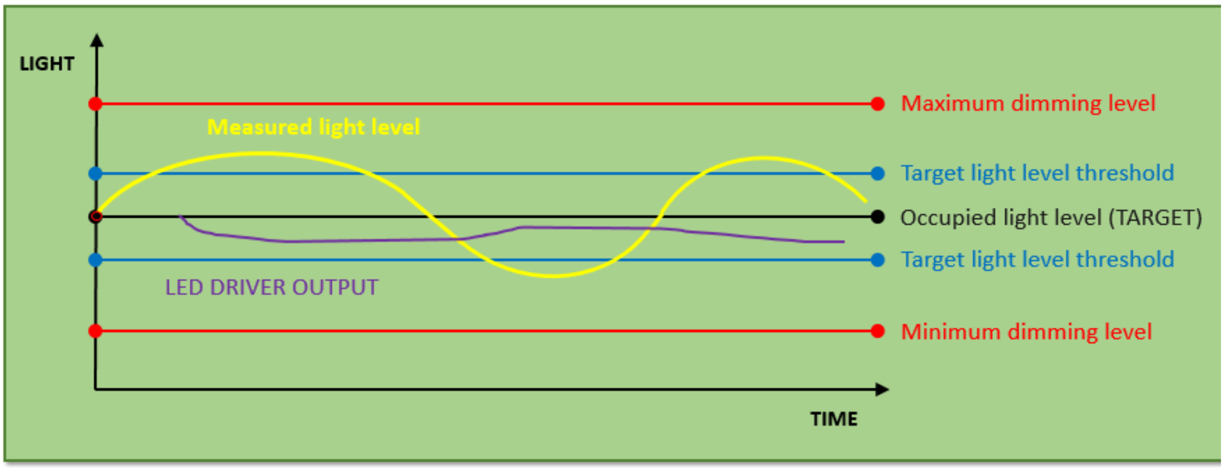

Figure 16: Daylight harvesting and Daylight Target Value.

Daylight harvesting and low light levels

The ActiveAhead daylight harvesting feature works in common lighting design scenarios. However, there are some specific considerations to be noted when as even as possible light levels are desired from different luminaires in the space. The light sensor measures the light level below the sensor. It doesn't care from which light source the light is coming from; meaning if the light is coming from another source than the luminaire itself or the sun. This causes the luminaire to start dimming down when there's enough of measured light and dimming up when there's not enough of light. The daylight harvesting algorithm in ActiveAhead tries to minimize the potential false triggers caused by non-daylight sources of light. But, there are circumstances where this is very difficult.

An example of a difficult case is such where there are many luminaires impacting the light sensor measurements of a sensor; e.g., this is often the case with sites having high ceiling heights. Another example is a case where the occupied light level is set low and thus the light coming from other sources make up a big portion of the measured light. The latter example is worse since typically a big change in the luminaire's light level is needed to influence the measured light level. Furthermore, such a luminaire has plenty of room to go up in light level to meet the target light level. In the worst case, one luminaire dims up while another one next to it stays off as it meets its target light level even when staying off. Even in the worst case the surface usually has the wanted light level making this an aesthetic issue instead of a lighting issue. Nevertheless, one can minimize these effects with a good lighting design in which luminaires with suitable output and light coverage are chosen for the space.

Single luminaire time-out parameters

To further clarify how the system controls the light we should also look at the next figure which shows how the light output is controlled vs. time. The related parameters (configurable if default values need to be changed) are listed in APPENDIX 1.

Figure 17 below shows a graphical presentation of How an ActiveAhead Control Unit controls the LED lighting element(s) output.

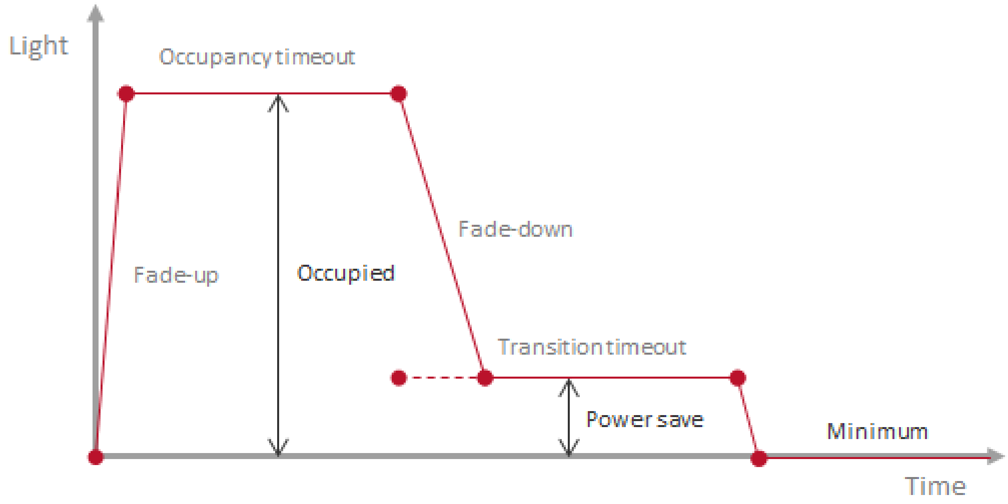

Figure 17: Light level states and timeouts.

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Ensuring optimised system behaviour

This section describes how to ensure proper self-learning and how to replace or add luminaires into an existing ActiveAhead solution.

Ensuring proper self-learning

Some situations may present challenges for the ActiveAhead self-learning algorithm. Follow the suggestions listed below to avoid problems:

- Avoid uneven distances between the sensors because uneven distances make balanced learning difficult. The reason for this is that distance affects the time it takes for a person to move between different sensors.
- Avoid sensor blind spots. If sensors do not cover the area of movement some movements will remain unnoticed.
- Avoid placing sensors meant to detect movement on a corridor above e.g. workstations. The human eye judges that the luminaire is learning from a nearby corridor when in fact the sensor is learning from the occupant presence of the workstation, which is independent from the movement in the corridor.
- Consider orientation of luminaire sensors in rooms separated from a corridor by a door. A sensor near the door is more sensitive to detect movement in the corridor when the door is open which may cause seemingly unexpected results.

Corridors with side paths

The ActiveAhead solution optimizes the energy savings while offering the comfort for the space users. In a corridor with side paths this can be often experienced. The luminaires on the beginning of the popular side paths will turn on when a person walks down the corridor. If the person continues along the corridor and doesn't turn to the side path, the luminaires which turned on to predict the movement will dim down faster to save energy.

Replacing luminaires

Replacing or adding new ActiveAhead luminaires is easy and normally consists only of mechanical installation and connecting for power, but in certain cases some programming might be required.

If a luminaire gets replaced, the new luminaire will join the mesh network the moment power to the luminaire is turned on. The new luminaire will immediately start the continuous learning process. The existing luminaires in the network will start learning about the movement of the new luminaire as well as the absence of the old one.
After a while the system will work as it did before the luminaire was replaced.

NOTE: Any grouping or other modified settings of the old luminaire are not transferred to the new luminaire and would need to be set up for the new luminaire using the ActiveAhead

Mobile App. In case the network ID of the installation has been changed (available as a service from Helvar or its partners) replacing a luminaire would require a service request.

Adding new luminaires

Sometimes it might become necessary to add a new luminaire into an existing ActiveAhead solution. In the simplest case, this would require just the luminaire installation. The checklist is identical to that in replacing a non-functional luminaire (see previous sub-section).

Wireless communication and recessed ceilings

In a typical office, recessed ceilings are often used to hide ventilation ducts and other HVAC system parts. Luminaires are typically installed on this recessed ceiling consisting often of panels which may be made of perforated metal sheets or metal frames with sound dampening materials. If a luminaire with a metal frame and an internally installed ActiveAhead Control Unit is installed on to a recessed ceiling some interesting effects may be observed.

In case the recessed ceiling consists of metal sheets or other conductive materials, the donut shaped radiation pattern together with the RF attenuation of the recessed ceiling material may cause the RF signal to propagate not downwards but mainly sideways between the actual architectural ceiling and the recessed ceiling. In some cases, the RF signal may “come down” from this space after more than several meters from the luminaire. While this may not be a major or even minor problem for the luminaire-to-luminaire communication, it may cause communication problems between luminaires and the mobile app. In practise a 2.4 GHz RF signal can “escape” from above the recessed ceiling panels through the ever present small gaps and holes of suitable size.

Impact of environment

ActiveAhead luminaires are designed to continuously measure light levels, detect movement and adjust luminaire light output accordingly

Furniture changes

The smart algorithm, enabled by the PIR sensor allows ActiveAhead luminaires to automatically adapt to changes in the local space. Moving furniture around will affect the paths along which persons walk about in the office thus causing relearning.

Outdoor factors

Changes outside the office space such as new buildings erected near the windows or tall trees being cut will typically cause changes to shadowing. More shadows mean that there will be less daylight which will cause the luminaires to output more light. If the building outside has reflecting glass windows there might be more daylight being directed through the windows in which case the light output from luminaires will be lower. ActiveAhead solution adjusts itself automatically to compensate for such changes.

References and further reading

For more information the ActiveAhead solution, components and applications please refer to the following guides:

- *"ActiveAhead Presentation"*
- *"ActiveAhead Mobile User Guide"*
- *"ActiveAhead FAQ"*
- *"ActiveAhead Luminaire Design Guide"*

The above listed documents are available for download at Helvar web site from the web site at www.helvar.com or by contacting Helvar Technical Support.

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APPENDIX A – System parameter default values

The table below lists the default values and value ranges (if applicable) for all ActiveAhead user programmable system parameters. If required a luminaire can be reset back to default values with the help of a mobile device which has the ActiveAhead Mobile App installed on it.

NOTE: Resetting luminaire parameters will also remove any group settings for that luminaire.

Parameter	Default value		Range
	Control Unit FW version		
	≤ 1.0.36	≥ 1.5.xx	
Occupied light level	85%	85%	10% +5%...100%
Power save light level	30%	20%	0%, 1%, 5% +5%...50%
Minimum light level	0%	0%	0%, 1%, 5% +5%...50%
Occupancy timeout	3 min	4 min	10 s, 30 s, 1 min, 1 min 30 s, 2 min, 3 min, 4 min, 5 min, 8 min, 10 min, 15 min, 20 min, 25 min, 30 min
Transition timeout	8 min	5 min	10 s, 30 s, 1 min, 1 min 30 s, 2 min, 3 min, 4 min, 5 min, 8 min, 10 min, 15 min, 20 min, 25 min, 30 min
Fade-up time	2 s	1 s	0 s, 1 s, 2 s, 4 s, 8 s, 16 s, 30 s, 60 s, 120 s, 180 s, 240s
Fade-down time	240 s	60 s	0 s, 1 s, 2 s, 4 s, 8 s, 16 s, 30 s, 60 s, 120 s, 180 s, 240 s
Daylight harvesting	ON	ON	-
Daylight harvesting minimum dimming level	30%	20%	0%, 1%, 5% +5%...50%
Daylight harvesting maximum dimming level	100%	+15 % [1)]	Not adjustable

Notes: *1) percentage points on top of* ***Occupied Light Level***

Table 4: ActiveAhead Control Unit default parameter values and ranges.

Default values explained

Light levels in different states

Occupied light level: default value 85 %

Lighting is designed using maintenance factors taking account aging factors of lighting like lumen output of luminaires caused by aging of light elements, accumulated dust, dirt or stains and room surface maintenance factors.
Lighting designers often use 0,8 as maintenance factor. For such maintenance factor the default **Occupied light level** of 85% ensures adequate lighting level.

Power save light level: default value 20 %

The **Power save light level** of 20% provides clear energy savings, yet providing illumination in the surroundings. Light levels under 20% are not recommended as default, because transition to any lower level in spaces like open offices might cause visible disturbances.

Minimum light level: default value 0 %

Minimum light level refers to continuous light level when space is unoccupied. The value 0% is typical when energy savings are to be maximized.

Timing and timeouts

Occupancy timeout: default value 4 min

The default value of 4 min is short enough to provide energy savings, yet long enough to maintain full lighting also in static work situations.

Transition timeout: default value 5 min

This default value is selected to keep the surroundings on power save level to ensure good lighting conditions. Shortening the **Transition timeout** value would not have significant impact on energy savings.

Fade-up time: default value1 s.

The value of 1 s allows rapid, but smooth switch on of the lights to enable good lighting conditions quickly.

Fade-down time: default value 60 s

The default value of is short enough for energy saving and long enough for human eye not to notice the dimming.

Daylight harvesting

Daylight harvesting: default value ON (enabled)

Daylight harvesting is enabled as default to maximize energy savings.

Daylight harvesting minimum dimming level: default value 20 %

The default value of 20% for minimum dimming level provides clear energy savings. Light levels under 20% are not recommended as default, because transition to any lower level in spaces like open offices might cause visible disturbances such as large changes in luminaire light output or harsh shadowing created by sunlight.

Daylight harvesting maximum dimming level: default value 15 % (percentage points)

Daylight harvesting is calculated automatically to be 15% percentage points above the Occupied light level. This allows compensation for reduced environmental light even above the default Occupied light level value when needed.

The daylight harvesting window is limited as default to ensure stable and reliable function of several luminaire sensors acting close together to prevent unwanted “chessboard” effect of luminaires.

APPENDIX B – Reset options

Resetting a single luminaire, luminaire group or the whole network with a mobile device

Resetting single ActiveAhead luminaires is possible by using a mobile device (smart phone, tablet, etc.) which has the ActiveAhead Mobile App (Android or iOS version) installed.

For more info refer to the *"ActiveAhead Mobile User Guide"* available for download at Helvar web site from the web site at www.helvar.com or by contacting Helvar Technical Support.

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APPENDIX C – Differences between the Android and iOS versions of Mobile App

ActiveAhead Luminaires can be controlled and programmed by the user with a mobile device such as a mobile phone or tablet if the device has the ActiveAhead Mobile App installed on it. Mobile App is available for both Android and iOS operating systems. There are some differences in the user interface and functionality between the Android and iOS versions of the Mobile App.

For further details concerning how to use the Mobile App and its user interface and the differences between the Android and iOS versions of the app please see a separate document named *"ActiveAhead Mobile User Guide"* available for download from the Helvar web site at www.helvar.com or by contacting Helvar Technical Support.