ABCIP

ASSOCIAÇÃO BRASILEIRA
DAS CONCESSIONÁRIAS
DE ILUMINAÇÃO PÚBLICA

TELEMANAGEMENT IN STREET LIGHTING

Technical specification guide

2nd Edition - 2023

EDITORIAL

PEDRO VICENTE IACOVINO
PRESIDENT OF ABCIP

Aiming to provide the population with public services of higher qualit, Brazilian cities have been chosing to partner with the private sector to modernize public lighting parks, which has proven to bring more comfort and safety to citizens, in addition to savings for public coffers with a drastic reduction in energy consumption. Public lighting service concessionaires have invested in innovation, adopting technologies capable of increasing productivity and energy efficiency in IP parks. In addition to replacing traditional light fixtures with LED technology, with increasing efficiency, there is a growing demand for systems remote management platforms, through which new services can be within the concept of smart cities can be offered.

This first review of the Public Lighting Telemanagement Guide, by Luciano Rosito, had the participation of professionals from 15 associated companies with outstanding performance in Brazil and abroad, and meets the needs arising from recent changes in the energy regulation of telemetering systems by INMETRO - Instituto Nacional de Metrologia, Qualidade e Tecnologia, which has been continuously working on updating the technical metrological regulation that ensures equipment certification.

The aim of this Guide is to continue assisting municipal public authorities and IP PPP project structurers in decision- making regarding public lighting management platforms and implementing accessories for smart cities from project conception. We are convinced that sharing this knowledge expands the scope of solutions based on municipal assets, generating potential gains in productivity and power efficiency.

This document was prepared by technology companies associated with the ABCIP, as listed below:

IOT DEVICE INDUSTRY
(INTERNET DAS COISAS)
www.bottomup.com.br

SERVIÇOS DE ILUMINAÇÃO
PÚBLICA DE EXCELÊNCIA
www.luzbr.com.br

SUA REDE
NACIONAL LORAWAN
www.everynet.com

TECNOLOGIA, SEGURANÇA E
QUALIDADE DE VIDA A TODOS
www.splice.com.br

LÍDER EM SOFTWARE
DE GESTÃO PARA
ILUMINAÇÃO PÚBLICA
www.exati.com.br

INFRAESTRUTURA
COMPARTILHADA DE
COMUNICAÇÃO
www.ihstowers.com

SOLUÇÕES PARA
ILUMINAÇÃO
PÚBLICA
www.kdliluminacao.com.br

SOLUÇÕES EM
ILUMINAÇÃO LED
www.ledstar.com.br

VIVEMOS A INOVAÇÃO QUE
TRANSFORMA A ENERGIA E AS CIDADES
www.m2mtelemetria.com.br

GERANDO CONECTIVIDADE E
HABILITANDO SOLUÇÕES DE IOT
www.nouvenn.com/br

CONTROLES INTELIGENTES
NA ILUMINAÇÃO PÚBLICA
www.novakoasin.com.br

SOLUÇÕES EM INTEGRAÇÃO
DE AUTOMAÇÃO
www.smartgreen.net

TECNOLOGIA E
SOLUÇÕES PARA
SMART CITIES
www.stengg.com

SOLUÇÕES EM ILUMINAÇÃO E
CONTROLES FOTOELÉTRICOS
www.tecnowatt.com.br

SOLUÇÕES EM ILUMINAÇÃO
PUBLICA E INFRAESTRUTURA
www.tradetek.com.br

Invited participants:

RECIFE CITY HALL - EMLURB
CONCESSIONÁRIA BHIP

SUMMARY

1.	ABOUT ABCIP	5
2.	GOALS	7
3.	GLOSSARY	9
4.	MAIN CONCEPTS OF A TELEMANAGEMENT SYSTEM FOR PUBLIC LIGHTING	12
4.1.	Conventional systems	14
4.1.1.	Photocontroller relay	14
4.1.2.	Magnetic keys	14
4.2.	Elements of a telemanagement system	15
4.2.1.	Integration in lamps	15
4.2.2.	Remote control equipment	16
4.2.3.	Group remote control equipment	17
4.2.4.	Drivers	18
4.2.5.	Controllers/Gateways/Base Stations	18
4.2.6.	Telemanagement software	19
4.2.7.	Connectivity	19
4.2.7.1	Topologies	20
4.3.	Main attributes of a Telemanagement System	22
4.3.1	Drive systems	22
4.3.2.	Light flux control and regulation	22
4.3.3.	Energy saving system	22
4.3.4.	Technologies for Time Reference	23
4.3.5.	Georeferencing	23
4.3.6.	Security and resiliency	23
4.3.7.	Other features	24
4.4.	Electricity Billing Operating Modes	24
4.5.	Evolution of the telemanagement system and ancillary revenue generation	24
5.	ADEQUACY OF REQUIREMENTS	26
5.1.	Requirements management	27
5.2.	Interoperability	27
6.	GUIDANCE FOR TELEMANAGEMENT SYSTEMS SPECIFICATIONS	28
7.	STANDARDS AND CERTIFICATIONS	33
ANNEX 1	DESCRIPTION OF TECHNOLOGIES	35

1. ABOUT ABCIP

The main goals of Associação Brasileira das Concessionárias Privadas de Iluminação Pública (ABCIP), created in 2017 as an entity governed by private law, are representing, stimulating, and facilitating the demands of public lighting concessionaires. Among the associates are public lighting service concessionaires (IP), digital system integrators, equipment and light fixture manufacturers, legal consultants, engineering design, and economic feasibility offices operating in the sector.

Through a permanent forum, ABCIP monitors and discusses projects developed in the public lighting market, deepening themes related to the sector and defending the interests of associates with public authorities.

ABCIP's main actions to make the demands of the sector viable are:

- Promote studies, courses, seminars, and agreements on issues related to public lighting;
- Cooperate and support other similar entities and business classes, national or foreign, in contact with regulatory and supervisory bodies of public lighting concessions;
- Promote appropriate legal measures against acts or standards that affect the activity or the legitimate, general, and uniform interests of its associates;
- Hold technical and commercial events on matters relevant to public lighting services;
- Develop research in favor of the sector's technological and institutional progress.

2. GOALS

2. OBJECTIVES

This manual aims to disseminate knowledge about telemanagement systems applicable to outdoor lighting. It presents the primary and general concepts on the subject, ranging from available technologies and their applications to aspects of technical specifications and regulatory requirements.
The manual aims to cover any outdoor lighting application of different sizes or types of installation, already anticipating possible technological evolutions so that additional equipment can be integrated into the system, adding new functionalities and applications.

The scope of the manual does not include detailed specifications related to the lamps. To this end, ABCIP recommends referring to the ABILUX website (www.abilux.com.br), where the reader can find a description of the ideal lights for a public lighting park with a remote management system.

The document prepared by ABCIP is intended for the audience involved with the subject of outdoor lighting in general, such as PPP project structurers (Public-Private Partnership), municipal managers and technicians, lighting designers, engineers, technical service providers, lighting installers in general, maintenance companies, and any other professionals working in the public/exterior lighting segment.

3. GLOSSARY

API (Application Programming Interface): The API is an application capable of communicating between software components. It is the set of programs that access the different verticals and layers of software.

Command board: Command board: Electrical switchboard with activation and protection equipment and the control system, which provides group activation of public lighting installations. It may or may not contain energy-measuring equipment.

Two-way communication: Surroundings between two or more elements where everyone can send and receive messages.

One-way communication: Surroundings between two or more elements in which one sends messages and the rest only receive them.

DALI (Digital Addressable Lighting Interface): Digital protocol dedicated to lighting control, which allows easy installation of robust, scalable, and flexible lighting networks. In the case of remote management, it is used as a communication protocol for orders sent by the remote control equipment to the driver.

Telemanagement equipment: Elements for remote control of a lighting installation operation. Management includes performing various actions, such as triggering, reading data, and analyzing alarms.

Remote control equipment: Equipment with communications that allow the sending of remote control orders to turn the installation on or off, reprogram specific calendars, and record the main events related to the installation.

GPS: Global positioning system, which allows the location of any object across the Earth, with an accuracy of up to centimeters.

IoT (Internet of Things): It is a concept that refers to a digital interconnection of everyday objects through the Internet.

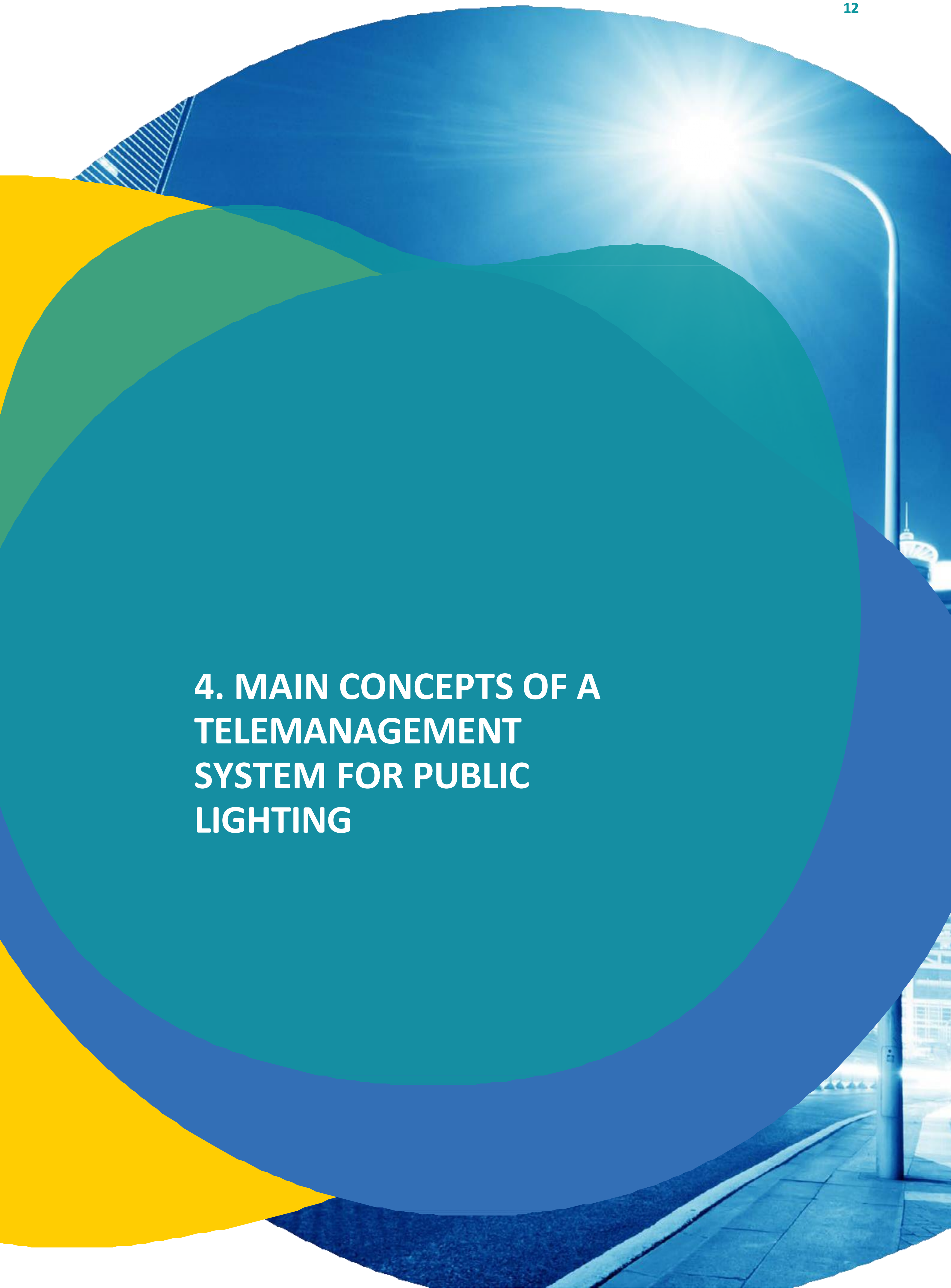
LED (Light Emitting Diode): Light source made of semiconductor material with two terminals. It is a p-n junction diode, which emits light when activated. If a suitable voltage is applied to the terminals, the electrons recombine with holes in the p-n junction region of the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the generated light (which depends on the power of the emitted photons) is determined by the bandgap width of the semiconductor. This technology has achieved significant deployment in lighting today.

NEMA (National Electrical Manufacturers Association): It is a US industry association responsible for many common standards used in the electrical field. Among others, it established a wide range of standards for the encapsulation of electrical equipment, as well as for systems for connecting photocells or communication nodes to lamps.

Remote management platform: Software for controlling and managing equipment data, which can be hosted in a local control center or web server.

Light sensor: Photoelectric sensor that responds to changes in ambient light intensity, varying the analog or numerical value of its output, depending on the received illuminance values in lux.

Asset and operation management software: Normally operated through the CCO, it has a georeferenced database and aims to manage maintenance activities and respond to incidents (deadlines, history, diagnoses, etc.). Events and functionalities that depend on information from/resulting from the Telemanagement software can be obtained through integration via API.



4. MAIN CONCEPTS OF A TELEMANAGEMENT SYSTEM FOR PUBLIC LIGHTING

Solutions for the automation of public lighting have existed for many years in Brazil. Until then, there were photocontroller relays for individualized commands and magnetic switches for controls in circuits, with the primary function of turning lights on and off through sensors that detected the light level (sensing) of the environment.

As technology evolves, we have a wide variety of lighting telemanagement systems, which are beginning to be broadly applied in Brazil. This market proliferated with the advent of PPPs in public lighting concessions in municipalities.

Public lighting has been recognized as the central infrastructure for implementing the concept of smart cities, given that its distribution covers a large geographic area of cities. Thus, each lighting point can become a connectivity point.

From the point of view of intelligent lighting control, there are several technologies with different levels of functionality and complexity.

- Conventional control systems:
  - Photocontroller relays; (Definition in subitem 4.1.1 below)
  - Magnetic keys; (Definition in subitem 4.1.2 below)
- Control Systems(Telemanagement):
- Remote control equipment; (Definition in subitem 4.2.2 below)
- Drivers; (Definition in subitem 4.2.2 below)
- Connectivity. (Definition in subitem 4.2.7)

Depending on the architecture of the proposed telemanagement solution, its elements may also include conventional system equipment containing at least telecommand equipment, telemanagement control application, and connectivity.

The main attributes of a Lighting Telemanagement System are:

- Turn the lamp on and off;
- Adjust the luminous flow with different programming cycles;
- Measure electrical quantities;
- Measure the electricity consumption;
- Monitor the status of light fixtures;
- Monitor the status of the communication network;
- Enable the implementation of energy-saving systems;
- Allow georeferencing of lighting points;
- Measure usage times accurately;
- Ensure an adequate level of security and resilience at all levels.

The elements that describe the telemanagement system and its main attributes are detailed below:

4.1. Conventional systems

4.1.1. Photocontroller relay

The photocontroller relay, also known as photoelectric relay, is a device that reacts to changes in ambient luminosity, activating a relay responsible for energizing a contactor or light fixture. This equipment basically consists of two main elements, a photocell and an electrical relay.

The photocell is an electronic component whose property is to vary the electrical resistance depending on the light incident on it, while the relay is a typically electromechanical component, whose function is to switch the state of its electrical contact from open to closed and vice-versa, thus connecting or disconnecting any load. In this way, with the interaction of these two elements, the photoelectric relay performs the functionality of turning on and off any load, depending on the light that falls on its photocell.

Its main advantage is the ability to react to meteorological phenomena that alter the local luminosity. Its disadvantage lies in the fact that other circumstances can affect the light received by its sensor, such as animals or elements on its surface, causing an unwanted activation.

Figure 1 – Photocontroller relay.
SOURCE: TELEMANAGEMENT COMMITTEE – ABCIP.

4.1.2 Magnetic Switch

The Magnetic Switches consist of equipment with the same functionality as the photoelectric relay, with the difference that they have a higher current- carrying capacity and a protection device, as they are used to control dedicated public lighting circuits with different lamps. Magnetic switches use a photocontroller relay, usually attached to its upper part, to switch the course through a contactor.

Figure 2 – Magnetic switch.
SOURCE: TELEMANAGEMENT COMMITTEE – ABCIP.

4.2 Elements of a telemanagement system

The Telemanagement systems that control the devices installed in the lamps or the control panels in the field must be designed in such a way as to allow the management of small to large projects and, therefore, be highly scalable.

The definition of communication technology is directly related to the architecture of the solution and the definition of which elements will be present in the final solution. A telemanagement system includes at least three essential elements: the remote control equipment, the control application, and connectivity.

4.2.1 Integration in Lamps

The most used alternative in Brazil is the connection of sockets for photocontroller relays, standardized by NBR 5123, based on ANSI/NEMA publications (see 6. Regulations and Specifications). In this case, the equipment must be prepared and have its connection terminals standardized so that the system is compatible and that they can be replaced by other equipment with the same characteristics.

In the case of public lighting, the ANSI C136.41 standard allows for quick connection of equipment through a turning and locking system. The most widespread standard today, given its versatility, is the 7-pin NEMA ANSI C136.41.

Figure 3 – 7-pin NEMA socket.

SOURCE: TELEMANAGEMENT COMMITTEE – ABCIP.

The aim of standardization is to allow the dissociation of telemanagement systems and light fixtures, facilitating the expansion of solutions, as these will not be subject to the specific aspects of lighting equipment. They will therefore depend only on the type of connection and common cabling, allowing users, both installers and city halls, to have compatible and interchangeable equipment.

4.2.2 Remote control equipment

Remote control equipment, also known as lamp controllers, are used in systems equipped with communication, which allows them to program/receive commands to turn on, off and adjust the luminous flow (dimming) of the lamps, as well as the calendar rescheduling, typically recording trigger and fault events. They are coupled to the lamps, generally, through sockets that follow the NEMA ANSI C136.41 standard of 5 or 7 contacts.

These devices can be composed by a combination of the following functionalities, integrated in single elements: photometer/photocell function (which may be in the individual controller or in the gateway), time reference, energy consumption meter (through actual or estimated measurement by time of use), flow regulation and control and monitoring of electrical characteristics. Through the photocell/photometer function, the system is able to turn on/off and dim the lamp, according to the variation in ambient luminosity. The hourly reference allows variations in the luminous flow based on hourly events, and can also be used to turn the lamps on/off.

The equipment has an internal power meter, capable of measuring the consumption of the set (lamp/driver) and electrical magnitudes. It also has the function of regulating the luminous flow of the lighting equipment.

This device may have the ability to generate pre-configured alarms through interfaces with sensors connected to it. The equipment must allow consultation and transfer of all data generated and stored. The alarm must be displayed automatically on the control panel or on the telemanagement software, without the need for manual intervention.

Despite the ability to communicate remotely, in the event of connectivity failure, it must ensure the lighting is turned on/off according to the last programming and parameterization received, or photosensing. Therefore, they must have accurate clocks (astronomical, internal) or other time reference mechanisms that allow the timekeeping preservation.

Figure 4 - Lighting controller

SOURCE: TELEMANAGEMENT COMMITTEE – ABCIP.

4.2.3 Group remote control equipment

With a function similar to the Magnetic Switches with Photocontroller, with greater circuit switching capacity and protection device, we also have Intelligent Telemanagement Systems capable of jointly managing several lamps installed in dedicated circuit architecture, being able to turn the circuit on/off, measuring the energy consumption of the course and detecting faults in the circuit, acting as a group on the dedicated public lighting circuit.
Control by group/circuit is carried out using dedicated control cabinets/boards to control the phases that form the circuits allocated to the lamps. Each cabin/board is equipped with equipment that can monitor and control the lights, in addition to reporting problems related to the operation of the circuits.
Control is based on cab/frame communication directly to the central control system. Below we mention some functionalities necessary for this operation to be carried out successfully:

- The booth/panel-based system must be able to monitor and manage the complete circuit infrastructure (light fixtures, cabling, power meter, etc.) from the central server
- Monitoring modules must be installed inside or close to electrical protection cabinets/boards or transformers.
- The system must only be installed on dedicated lighting circuits, as it will control the complete course. Ex: Squares.
- All alarms or failures must be monitored and reported at the circuit level; it is not possible to identify the specific point of failure.

Note 1: This type of equipment can be an alternative to light fixtures/equipment incompatible with remote management without performing the control and dimming.

Note 2: In this type of configuration, compliance with INMETRO ordinance No. 221 is not foreseen.

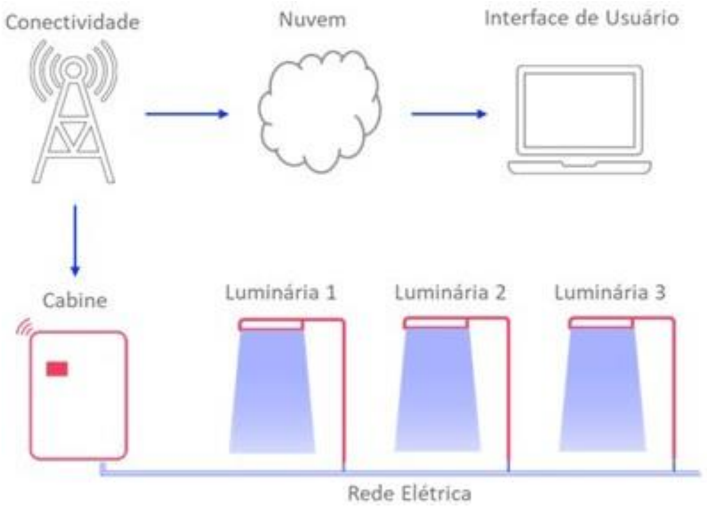


Figure 5 – Group remote control

4.2.4 Drivers

4.1.4. The driver is the device integrated into the lamp, responsible for powering the LED set incorporated in it. It performs the regulation of the output current for the LED, guaranteeing the nominal power for the lighting equipment.

The lamp supplier must parameterize this element to meet the specific needs of the drive system that will be implemented in the project. For example, the interface type to be used for controlling and regulating the luminous flux if provided for in the installation.

The drivers, when applicable, can operate with two control protocols for the lamp flux regulation; they are DALI, 1–10V (in some cases 0 to 10V). For public lighting in Brazil, the 1-10V protocol is widely used, which follows an open standard regulated by IEC60929. It is an analog and unidirectional protocol in which the variation of the continuous voltage signal between 1 and 10V produces a corresponding variation of the luminous flow.

4.2.5 Hubs/gateways/base stations

The hubs, gateways, and base stations connect the remote control equipment (lamp controllers) to the remote management control application, which is located in the system's monitoring center. There are architectures where these elements are absent, featuring a direct connection between the remote control equipment and the management application.

The communication between these devices and the remote management control application can occur through different technologies: LPWAN, 3G/4G, Optical Fiber, Ethernet, Radio, or Satellite Link.

Figure 6 – Hub / Gateway.

Figure 7 – Base Station.

4.2.6 Remote management software

The tool or process allows effective control and remote management by the user. Ideally, it should consist of web and application (or responsive web) versions, allowing users to use it centrally, for example, in management centers (CCO) and the field during the system installation process. The application must have an API (Application Programming Interface) for integration with other systems.

A primary application should allow the following:

- View critical features such as:
  - Number and power of light fixtures;
  - Energy consumption and electrical quantities;
  - Operating time of the lamps;
  - Luminous flux adjustment rules (dimming)
  - Lamp condition (on/off and/or regular/failed)
  - Lighting park alerts;
  - Park of georeferenced lamps in a cartographic way.

- Send commands to:
  - Turn light fixtures on and off, individually or in groups;
  - Program operation and alarms;
  - Equipment firmware update;
  - Light flow regulation.

- Allow the issuance of all control reports through the platform or APIs, as specified in item 4 (Software platform requirements) of section 5 (Guidelines for the specification of Telemanagement systems) of this manual.

Records of electrical parameters and energy consumption: Ensure the storage of electrical and operating parameters sent by the controllers. The main parameters used are voltage, current, active power, active energy consumption, power factor, and running hours counter;

Alarm control: The Telemanagement software must manage the alarms generated by the reading of electrical magnitudes, such as overvoltages and undervoltages, the status of lighting fixtures improperly switched on or off;

Finally, it is crucial that the application has different levels of access and security, ideally with a double security factor and measures to prevent intrusion by third parties.

4.2.7 Connectivity

Multiple technologies and topologies can connect equipment in a Telemanagement System. Each technology presents different characteristics in its structure. However, for the telemanagement system to be efficient, it is necessary to pay attention to some points:

- **Technology bidirectional capability:** Ability to send and receive information, as well as send commands to remote control equipment through the control application;
- **Remote Update - OTA (Over The Air):** Ability to remotely update the parameters of the Telemanagement equipment, reducing the risk of manual intervention in the event of failures or the need for correction, as well as updating the module's firmware;
- **Cryptography:** The user must demand cryptography and/or proven secure elements to avoid cyber attacks on the telemanagement system through the invasion of communication systems.

Among the leading technologies used by solution providers in Brazil, some stand out:

- 6LowPAN
- Zigbee
- WiFi
- LoRaWAN
- LTE 4G NB_IoT
- UNB-LPWA
- Bluetooth
- RF Mesh / Star
- Wi-SUN

Note: In Appendix I of this manual, there is a brief description of each of these technologies.

Given the constant evolution in the telecommunications sector, it is emphasized that there is no limitation to the use of different technologies. In practice, connectivity represents how messages containing information or commands will be exchanged between the command centers and each point or set of lighting. In this sense, the most relevant thing for the demander of a telemanagement system is to clearly define the performance requirements, leaving under the contractual responsibility of the concessionaire the definition of the technology to be used, as well as the delivery of the requirements defined in the contract through service level agreements - SLA.

1. Topologies

- **Star topology**

The point-to-multipoint topology, also called star, comprises several telecommand equipment that connect to a central node or a base station, which sends information to the control center.

In the event of a failure in a specific node, the rest of the network nodes continue to function normally. Failure in the central node does typically not affect the network, as each telecommand device automatically searches for another base station, creating a natural redundancy.
A Mesh Network is an alternative to traffic guidelines for small data packets and high availability.

It comprises several nodes (telecommand equipment) that behave as repeaters/routers, forming a single and extensive network, enabling data exchange between the client and any node. The main feature is the ability to exchange data between any network member, composing the communication infrastructure, which makes it possible to send messages from one node to another, passing through different routes.

Figure 8 – Star topology.

SOURCE: HTTPS://TVILIGHT.COM/PRODUCTS/STREET-LIGHT-CONTROLLER/NEMA-IOT-STREET-LIGHT-CONTROLLER-OPENSKY_NEMA/

- **Mesh Topology**

A Mesh Network comprises several nodes (telecommand equipment) that behave as repeaters/routers, forming a single and extensive network, enabling the exchange of data between the client and any node. The main feature is the ability to exchange data between any network member, composing the communication infrastructure, which makes it possible to send messages from one node to another, passing through different routes.

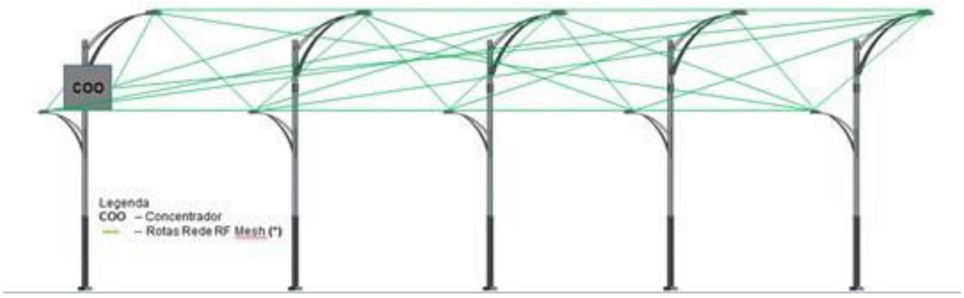


Figure 7 – Mesh Topology.

SOURCE: TELEMANAGEMENT COMMITTEE - ABCIP

4.3. Main attributes of a Telemanagement System

Below are the main characteristics present in a remote management system for public lighting:

1. Drive system

The activation systems are used so that the lamps turn on and off at predetermined times or according to specific conditions, such as light levels or motion detection. For safety reasons, they must ensure the lighting is turned on if they enter a failure mode.

The drive systems apply to any lighting, as they only control the switching on and off. They can be in the remote control equipment or the electrical switchboard that serves the installation, typically carrying out the command through a contactor. They can be installed in the lamp, depending on its type. In the latter case, electrical protections and electricity meters may be incorporated.

2. Light flow control and regulation

Lighting systems with dimmers can be present in two ways:

- In control panels/circuits dedicated to public lighting: Equipped with a control system responsible for the on/off commands of the lamps together, individual regulation is not possible;
- At the lighting/individual control point: In this case, the flow control is present at the lighting point, typically coupled to LED lamps prepared for remote management.

4.3.3. Energy-saving system

This concept relates to the ability to adapt lighting to actual needs, whether in brightness or use. In this way, the objective is to save energy during operation.

In summary, the use of lighting with an energy-saving system allows the regulation of the luminous flux to obtain the necessary lighting levels for each period of use. For example, changing the road category during the night due to the reduction in the flow of vehicles may allow the decline of the luminous flux to a lower level, thereby obtaining a decrease in consumption.

It should be noted that the technology used in the lamp construction should allow the regulation of the luminous flow through control interfaces.

For a correct implementation of this concept, it is necessary to use a telemanagement system based on an operational control center capable of managing the operating profiles of the control devices installed in the field.

4.3.4. Technologies for Time Reference

There are several technologies to measure time reference. Below we present the main ones:

- **Astronomical Clock:** Implementation in which the activation of the lamp depends on algorithms, or pre-programmed tables, which allow to know the times of sunrise and sunset at the installation site;

- **RTC (Real Time Clock):** It is a clock integrated into the remote control equipment, responsible for autonomously keeping the time count (date/time). It has a battery or a supercapacitor to maintain the RTC in the event of an interruption in the power supply from the network;

- **Network Synchronized Clock:** The time reference (timestamp) is constantly synchronized with the telemanagement system, always keeping it updated.

- **GPS (Global Positioning System):** It is a satellite navigation system capable of providing the receiver with a time reference, with precision in the nanoseconds order.

Therefore, the temporal metrics presented above are responsible for activating the lighting control devices, providing gains related to the consumption of electricity or security, and the ability to adapt to time changes (local time policy, daylight and winter saving time, and other desirable time settings).

4.3.5. Georeferencing

Georeferencing is always present in telemanagement systems, whether through GPS integrated into remote control equipment or external tools used to inform geographic coordinates when implementing the project, being duly registered on the Telemanagement System platform.

4.3.6. Security and resiliency

A secure and resilient management system should forecast system stress scenarios and ways of working around each potential problem. One should think about a flexible infrastructure, which can be in the cloud or a local data center but with high levels of access and security.

Access to the lamp park management system must have additional security procedures, such as:

- Double factor password authentication;
- Different access profiles;
- Encryption in the elements that make up the management system, including connectivity and communication protocols;
- Database redundancy in the cloud or a local data center.

4.3.7. Other features

As an alternative to the previously explained operation, there may also be other functionalities, as shown below:

- **Activation of the lamps from the ambient lighting measurement:** It allows them to act automatically in critical situations, such as meteorological factors and diurnal darkening, among others. Its operation is based on the luminous interaction of the environment with high-precision photocells/photometers;

- **Functionality of power supply interruption detection):** The system can send an alert to the Telemanagement platform (promptly), informing of the interruption of the energy supply to the lamp. The functionality may be implemented by hardware or by software.

- **Adjustment of the luminous flux depending on the traffic volume on the road:** Its reference is statistical measurements obtained through historical series or sensors based on artificial vision and radars, among others.

4.4. Electricity Billing Operating Modes

In line with ANEEL Dispatch No. 3,423 of November 29 (or any update that replaces it), there are three operational modes for billing the electricity consumed by a public lighting point equipped with telemanagement systems, which we mention below:

Item 5 - ESTIMATE BY PERIOD OF USE AND LOADING

Item 6 - ESTIMATE BY PERIOD OF USE, LOAD AND DIMMING EVENTS

Item 7 - CONSUMPTION MEASURED BY THE IP MANAGEMENT SYSTEM WITH LOAD CONTROL DEVICES

4.5. Evolution of the telemanagement system and ancillary revenue generation

The Telemanagement systems in public lighting have the following basic functionalities: control, monitor (status of light fixtures and alarms), and measure magnitudes and electricity consumption of general lighting points.

Due to the characteristics of the architecture of public lighting installations, such as symmetrical distances between the lamps, access to power

distribution of electricity at each point, large capillarity, targeted, among others, it is easily possible to add additional functionalities to telemanagement systems, which enables the generation of ancillary revenues for concessionaires and the improvement of urban infrastructure in cities.
As examples of additional services, the following stand out: maintenance hole sensing, solid waste and dumpster management, intelligent public parking, air quality measurement, urban noise sensors, river level measurement, river galleries and rainfall stations, and urban asset tracking, among others.

Thus, value is added to the solution, providing the appearance of ancillary revenues based on the existing infrastructure.

5. ADEQUACY OF REQUIREMENTS

Below are relevant points to be considered when adopting a telemanagement system for lighting.

1. Requirements management

When selecting a telemanagement system, it is recommended to evaluate the following aspects:

- Connectivity technologies;
- Field network reach and expansion capacity – scalability;
- Redundancy in the face of the failure of gateways or base stations
- Ability to program the number of measurements to be performed;
- Data communication network security.

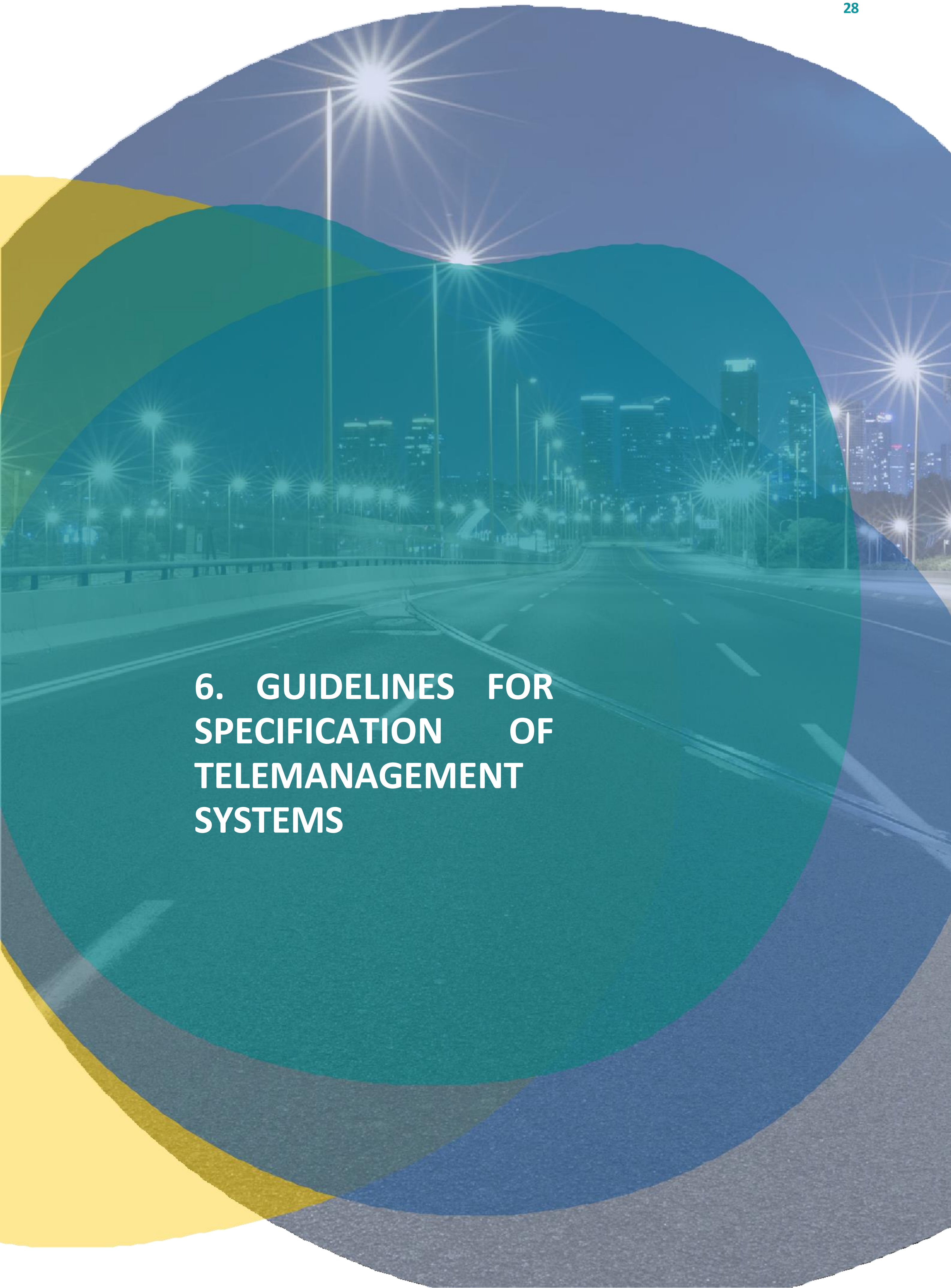
Other aspects that can be evaluated:

- The integration of the lamp controller – whether incorporated within the lamp or coupled using the NEMA standard;
- The experience of each manufacturer, its after-sales services, and human resources, as they are an essential part of the project's success and the system's continuity.

5.2 Interoperability

One of the critical assumptions when choosing a remote management system is the system's interoperability with other platforms, for example, systems for the management and maintenance of public lighting, in addition to future applications in smart cities. This is a fundamental factor for the municipalities since the municipality will not be bound by the technology or the provider when contracting an open or integrable system.

To facilitate the integration of different platforms, APIs must be requested to make the various systems easily integrate with other platforms. The ease of an API integration is given, in many cases, by the protocol used, as it will allow a greater range of possibilities for integration with other functionalities. To assess whether a system can integrate through APIs, the user can request the presentation of statements from other customers who have used the integration or access to the documentation of the same API.



6. GUIDELINES FOR SPECIFICATION OF TELEMANAGEMENT SYSTEMS

The table below presents a suggested set of requirements that align with the current Telemanagement systems stage.

1. Telemanagement performance factors

To define the performance factors of a telemanagement system, some aspects must be considered.

One of the first aspects to consider is how the Telemanagement Systems operate concerning communication with the controllers. This communication can generally take place in two ways, both of which are effective in their way of operating and not necessarily exclusive. Are they:

- **Format of operation by exception:** in this format, the central system does not proactively search for communication with the controllers – communication takes place when the lamp controller sends information to the system (without questioning), for example, energy consumption or the recording of an event.

- **Operation format per query (scan):** in this format, the central system asks the controllers every certain period about their operation and waits for the controller's response to update the operation data (fault, energy, etc.).

Performance indicators, depending on how the system operates, can be different. To unify and create only one way of validating the network operation, the indicator related to the response time from a user request is recommended, as described in the table below.

1 - PERFORMANCE FACTORS	
Availability of connectivity for lamp controllers (remote control equipment). This index is measured by checking data from controllers. Devices must provide at least one piece of information on the 24-hour period.	>95% of devices reporting information to the central system in the requested period
Maximum response time interval, so that the information sent by a remote control equipment is presented in the telemanagement management system, after a specific request by an operator. (maximum time for each segment – sending and returning). This indicator should be measured on a sample basis, and should only be performed when operating in a stable environment*.	Maximum time of 180 seconds
Other relevant factors	Active devices must always be ready to provide any anticipated data requests in the provided system (in a stable environment*). In the event of connection loss, you must report the lack of connection. The system must have confirmation of sending and/or receiving instruction(s) (lighting, reading, programming) which must be registered (log) after the request or programming.

*The stable environment is characterized as the circuits/lights are energized, and connectivity is verified and working at all levels (operator, control system, concentrator, and cellular network)

2 - REQUIREMENTS FOR REMOTE CONTROL EQUIPMENT (CONTROLLERS)	
Type of communication	Radio frequency communication.
Homologation	ANATEL and INMETRO homologation
Cryptography	Minimum 128-bit encryption.

Operating profiles and maintenance of profiles in case of power failure	Every system is susceptible to failure. Therefore, the controllers must be able to guarantee the lighting of the roads and operate the lighting point correctly, regardless of failures. This is possible through some of the following basic functionalities: • In case of failure in communication between the controller, the concentrator, the base radio or the Control and Operations Center, the controller must continue operating normally, according to its pre-configured parameters, time reference, and photocell/photosensor; • Have the ability to maintain the operating hourly reference base; • Have the ability to preserve the hourly pre-settings of operation and dimming.
Dimming control	Dimming control through time profiles and/or light sensor.
Record of electricity consumption	Storage of electricity consumption in non-volatile memory.
Real-time clock	Real-time clock or clock synchronization via hub or base station or network (cellular or other technology).
Measurement of electrical quantities	Measurement of electrical quantities – Active energy, voltage, current, active power and power factor .
Lighting alarms	Lighting off/on, undervoltage and overvoltage indication.
Control interfaces	0-10 V or DALI control interfaces.
Cutting device	Have a power cut device for the driver.
Connectorization standard	Have a version for a NEMA socket with 5 or 7 contacts, according to the ANSI C136.41-2013 standard.
Other requirements	The telemanagement system must have a photocontroller/photocell (or precision photometer) function capable of switch on the lamp in the event of a decrease in ambient luminosity.

3 - REQUIREMENTS FOR CONCENTRATORS/BASE STATION	
Encryption	Encryption, at least 128 bits, without restrictions on formats, with remote control equipment and the software platform.
Connectivity	Connectivity with any TCP/IP technology for the software platform.
Communication with remote control equipment.	Through radio frequency.
Homologation	ANATEL homologation.
Update	Remote firmware upgrade (FOTA – Firmware over the Air).
4 - REQUIREMENTS FOR THE SOFTWARE PLATFORM	
Georeferencing	Integrated cartography.
Programming and operation of remote control equipment	Individual or group programming and control.
Scheduling	Scheduling time profiles.
Encryption	No minimum of 128 bits.
Hosting:	Cloud or local (cloud backup).
Accessibility	Through Internet browser, with different levels of access.
Reports	Graphic presentation and consumption reports by selected period.
Data export	Export of telemetry, for a selected period, in .csv or .xls format
Secure connection	Via HTTPS.
Scalability	Use of database with high scalability.
Access levels	Access with administrator, editor or viewer levels, through encrypted access password.
Integration	API for integration with other systems.

7. REGULATIONS AND CERTIFICATIONS

- Anatel:

  - **Anatel Resolution No. 715, of 2019: Regulation for Conformity Assessment and Homologation of Telecommunications Products** (https://www.in.gov.br/en/web/dou/-/resolucao-n-715-de-23-de-ou-tube-of-2019-223850480).

  - **Anatel Resolution No. 680: Regulation on Restricted Radiation Radiocommunication Equipment** (https://www.in.gov.br/materia/asset_publisher/Kujrw0TZC2Mb/content/id/19145767/do1-2017-06-29-resolucao-n-680-de-27-de-June-2017-19145667).

- Act No. 1120, of February 19, 2018 - Technical requirements for Electromagnetic Compatibility (https://informacoes.anatel.gov.br/legislacao/atos-de-certificacao-de--products/2018/1181-ato-1120).

- Act No. 14448, of December 4, 2017 - Technical Requirements for Equipment Conformity Assessment of Restricted Radiation Radio Communication (https://informacoes.anatel.gov.br/legislacao/atos-de-certificacao-de--products/2017/1139-ato-14448).

- ABNT NBR 5123: 2016 Corrected Version: 2016 - Interchangeable photocontroller relay and lighting socket — Specification and tests (https://www.abntcatalogo.com.br/norma.aspx?ID=363645).

- ABILUX booklet for LED lamp specification (https://abilux.com.br/docs/abilux_cartilha_2017.pdf).

ANNEX 1 - DESCRIPTION OF TECHNOLOGIES

- **Bluetooth –** Used in short-range and high-speed communications, based on the IEEE 802.15.1 standard. Typically for small checks, such as checking the programming of nearby equipment.

- **WiFi –** It uses the IEEE 802.11 standard. Easy to install and manage, with several devices available in the market. However, they have the disadvantage of their short range. In response to this problem, WiFi Max was developed at a high cost.

- **Zigbee –** It adopts the IEEE 802.15.4 standard. One of its main characteristics is the low consumption, operating in a mesh topology (Mesh), being easy to implement. Although it can work in sub-giga bands, it typically operates at a frequency of 2.4 GHz.

- **6LowPAN –** Like Zigbee, it is based on the IEEE 802.15.4 standard. It has a mesh topology, low consumption, and the ability to communicate with IP devices, as it uses the IPv6 protocol.

- **LoRaWAN –** They are "ad-hoc" networks with medium to low data transfer rates. The technology is open, and the solution implementation can use the service provider's own network or an existing commercial network for neutral use. It belongs to the vendor that implements it and is widely used with IoT devices.

- **LTE 4G NB_IoT –** It is a public cellular network within the LPWAN – Low Power Wide Area Network category, networks with low energy consumption and capable of covering large areas. This network uses the LTE – Long Term Evolution standard, within the 3GPP standard, making use of the 4G network and using the guard bands and the narrow network protocol specialized for the Internet of Things (NB_IoT – Narrowband – Internet of Things). Using a regulated frequency of 700 or 1,800 MHz, already available in all municipalities in Brazil. It differs from a 4G network because it has a long-range, can be targeted, and allows use in battery-powered devices.

- **UNB-LPWA –** It is a standard ETSI-LTN network with a star topology. It covers large areas and massive projects without needing a line of sight between the equipment and is characterized by the natural redundancy of communication.

- **Wi-SUN –** A protocol for mesh networks based on the IEEE802.15.4 (g/e) standard, which has 6LowPAN in its composition with some adaptations. One of the differentials concerns the security of communication between devices by establishing asymmetric keys. The protocol also determines the use of frequency hopping (FHSS) for optimized use of the communication spectrum.

ABOUT US

ABCIP

Pedro Vicente Iacovino
CEO

Edward Isaiah Gurevich
Institutional Director

Luca Avancini Siqueira
Technology Director

Eliana Stellino
Institutional Advisor

Leila Reis
Communication Advisor

Luciano Rosito
Coordinator of the Telemanagement Committee

Committee participants: Adalberto Battistini (SIGNIFY/TELENSA), Alex Sato (SPLICE), Augusto Ohashi (NOUVENN) Bruno Souza (LEDSTAR/UNICOBA),
Calisto Sena (TRADETEK), Denis Naressi (EXATI), Felipe Fulgêncio (M2M TELEMETRY), Fred Braga (BOTTOMUP),
Gadner Vieira
(M2M TELEMETRIA), Giuseppe Glionna (IHS TOWERS), Gustavo Zarife (EVERYNET), Haim Hamaoui (TELENSA/NOVAKOASIN), Hector Felix (SPLICE), Jair Sakae (KDL ILLUMINATION), Klaus Lacher (KDL ILLUMINATION),
Luca Avancini Siqueira (ST ENGINEERING), Luciano Rosito (SIMON/ TECNOWATT), Marcio Pinto (ZOPONE), Nilson Tanji (SMARTGREEN), Otavio Silva (EVERYNET), Sandro Vieira (NOUVENN)

Associação Brasileira das Concessionárias Privadas de Iluminação Pública www.associacaoabcip.com.br

Rua Padre João Manuel, 923 – 8th floor São Paulo - SP

contato@associacaoabcip.com.br
Phone: (11) 3897-6817 / (11) 98084-1238

ABCIP
ASSOCIAÇÃO BRASILEIRA DAS CONCESSIONÁRIAS DE ILUMINAÇÃO PÚBLICA